Astrophysics Division's Joint Technology Prioritization Process

Presentation at 233rd AAS Meeting

January 6, 2019

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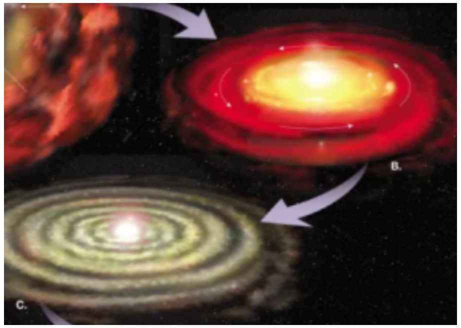
Agenda

- Astrophysics science themes and the Program Offices
- Technology Gap Solicitation, Prioritization, and Reporting
- Strategic Missions and Technology Gaps
- New Joint Process
- SAT Proposal Call
- Takeaways

Astrophysics Science Themes and Program Offices

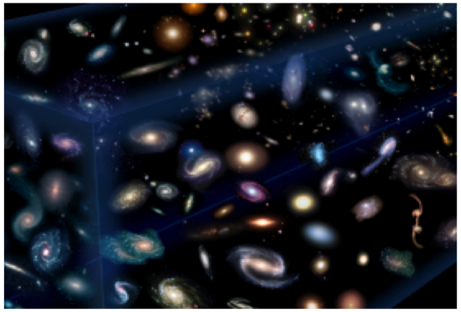
The organization of NASA's Astrophysics Division (APD) includes three science themes supported by three Program Offices (POs):



How did we get here?

➔ *Cosmic Origins Program (COR)*

Program Office at GSFC



How does the universe work?

➔ *Physics of the Cosmos (PCOS)*

Program Office at GSFC

Are we alone?

➔ *Exoplanet Exploration Program (ExEP)*

Program Office at JPL

Program Offices Manage Strategic Technology Development

- **APD established the Strategic Astrophysics Technology (SAT) program to support the maturation of key technologies for potential infusion into space flight missions**
- **An important role of the POs is to manage technology developments by SAT and direct-funded projects**
- **The POs also solicit and prioritize technology gaps to inform the SAT program's solicitation and selection, and to accomplish other Program objectives**
  - Until 2017, the prioritizations were done annually, and separately by the three POs
  - The PCOS/COR and ExEP POs followed a different process and timeline, and reported their results in three separate publications

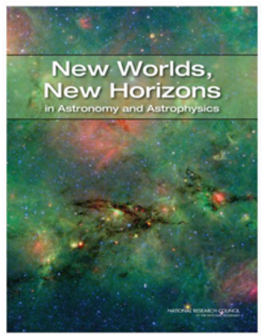
Integrating APD's Technology Prioritization, Solicitation, and Reporting Processes

Beginning this year, the POs' technology gap solicitation, prioritization, and reporting processes will be integrated to consolidate and streamline efforts and improve ability to:

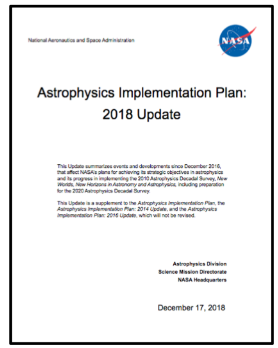
- Inform the community of APD technology progress and direction
- Communicate strategic technology priorities across science Programs
- Promote technology innovation and maturation
- Inform technology planning and investment to maximize strategic impact across Astrophysics
- Foster technology cross-utilization

Technology Gap Prioritization Objectives

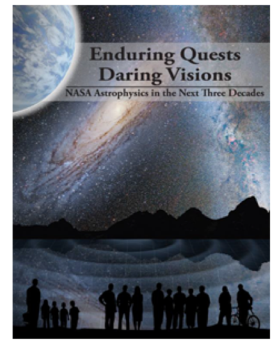
- **Identify technology gaps** applicable and relevant to Astrophysics strategic objectives as described in the Astronomy & Astrophysics Decadal Survey, the Astrophysics Implementation Plan (AIP), and the Astrophysics Roadmap



2010 Decadal Survey



APD Implementation Plan



NASA APD 30 Year Vision

- **Rank technology gaps** to inform APD strategic technology development planning and investments (SAT and directed funding)
- **Inform SAT solicitation** and other NASA technology development programs (APRA; SBIR; and other SMD, OCT, and STMD activities) of our technology needs
- Results inform technology developers of Program needs to help **focus technology development efforts and leverage existing technologies** when possible, and avoid duplicating development efforts
- Process **improves transparency and relevance** of Astrophysics technology investments
- Process **informs and engages the community** to optimize Astrophysics technology development process
- **Leverage technology investments** of other organizations by defining Astrophysics strategic technology gaps and identifying NASA as a potential customer

Strategic Missions and Technology Gaps

Strategic astrophysics missions are ones APD is developing, participating in, or interested in, to respond to high-priority science questions or mandate. These are missions identified as priorities by the current Decadal Survey; identified for execution by APD; and/or that inspired broad community interest, e.g. as captured in the Astrophysics Roadmap. These missions are not competed or PI-led, though they may carry competed instruments developed by PI-led teams.

- Current strategic missions:
  - Missions in formulation or implementation: JWST, WFIRST, Euclid, XRISM
  - Decadal survey mission concept studies: HabEx, LUVOIR, Lynx, OST
  - Missions identified for potential contributions: LISA, Athena
  - Operating mission with technology needs: SOFIA
  - CMB Polarization Surveyor per Roadmap and in 2010 DS: Inflation Probe
  - Visionary missions per Roadmap: Black Hole Mapper, Cosmic Dawn Mapper, ExoEarth Mapper, and Gravitational Wave Mapper
- Strategic missions relevant for technology gap submission for prioritization are shown above in blue

Opportunities of Strategic Technology Gaps

- Strategic technology gaps identify where and how our current state of the art is insufficient to enable future strategic missions
- Submitting technology gaps informs APD about our community's technology needs, and allows you to help shape future APD technology investment and flight missions
- Technology gap submissions are accepted for 2019 prioritization from now through June 1, 2019
- Large-mission concept studies' Science and Technology Definition Teams (STDTs) will be asked to update their gap inputs for submission at the same time
- Gap submission forms are available on our websites:
  - https://apd440.gsfc.nasa.gov/technology/
  - https://exoplanets.nasa.gov/exep/technology/technology-overview/

The New Joint Process

- **Joint solicitation of technology gaps from the community:**
  - The three POs jointly coordinate the next technology gap solicitation, prioritization, and reporting cycle, and carry them out on the same schedule
  - This cycle will now be a biennial process (every other year, **starting in 2019**)
  - POs will collect gaps together and determine which Program carries each gap
- **Coordinated prioritization of technology gaps:**
  - Same prioritization criteria and scoring metrics used by all POs
  - Joint listing of all prioritized Astrophysics gaps published every other year
- **Joint program technology reporting:**
  - Joint publication called the “Astrophysics Biennial Technology Report” or “ABTR” (no more Program Annual Technology Reports, PATRs)
  - The three POs host a common “AstroTech” database of all managed technology projects

Prioritization and Coordination Among Astrophysics Program Offices

- Technology gap **prioritization is changing from Program-science-centric** to **Astrophysics-wide**
- Technologists from PCOS/COR/ExEP work together:
  - Determine for each gap which Program science goals would benefit most from closing it, after which it is prioritized by that Program
  - Technologists from the three POs jointly prioritize gaps for each of the Programs
  - After the three POs complete their prioritization, the technologists merge the three priority lists into a single prioritized Astrophysics technology gaps list
- Technology gaps are prioritized by the PCOS and COR Technology Management Boards (TMBs) and by the Exoplanet Technology Assessment Committee (TAC) according to a uniform set of criteria

Uniform Prioritization Criteria

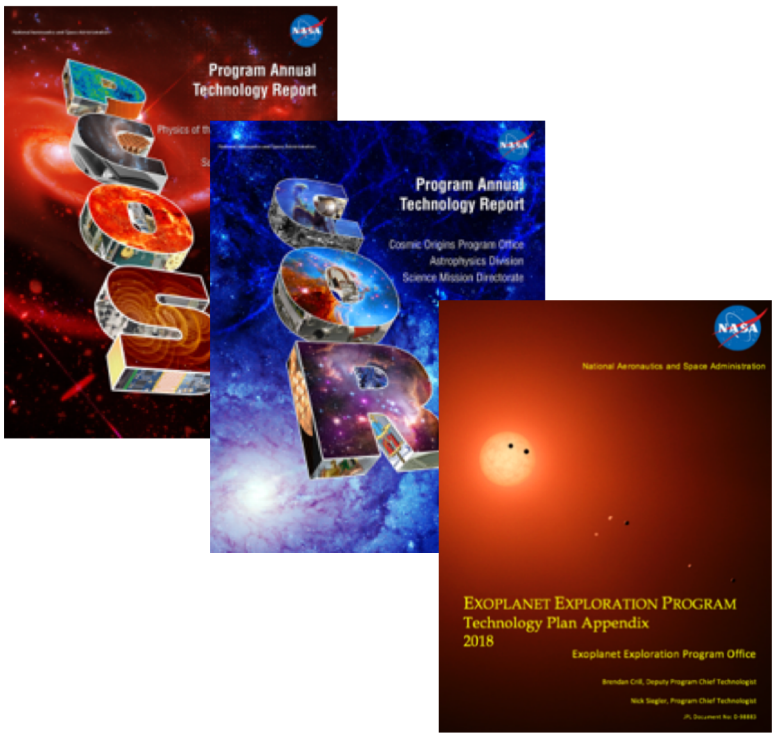
- ***Strategic Alignment***: How well does the technology align with astrophysics science and/or programmatic priorities set out in the Astrophysics Implementation Plan, Decadal Survey, or Astrophysics Roadmap?
- ***Benefits and Impacts***: How much impact does the technology have on applicable missions? 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?

Uniform Technology Gap Prioritization Scoring Guidelines - Draft

Criterion	Weight	Max Score	Max Weighted Score	General Description/ Question	4	3	2	1	0
Strategic Alignment	10	4	40	How well does the technology align with Astrophysics science and programmatic priorities of current programmatic guidance (i.e., AIP, Roadmap, Decadal Survey)?	Technology enables science within mission concept receiving highest current programmatic consideration	Technology enables science within mission concept receiving medium current programmatic consideration	Technology enables science within mission concept receiving low current programmatic consideration	Technology enables science within mission concept mentioned in Decadal Survey but not included in AIP	Technology does not enable science within any mission concept considered by current Astrophysics programmatic guidance
Benefits and Impacts	8	4	32	How much impact does the technology have on applicable mission(s)? To what degree does the technology enable and/or enhance achievable science objectives, reduce cost, and/or reduce mission risks?	Critical and key enabling technology; required to meet mission concept objectives; without this technology mission would not launch or science return would be significantly impaired	Highly desirable; not mission-critical to mission objectives, but significantly enhances science capability, reduces critical resources needed, and/or reduces mission risks; without it, missions may launch, but science return would be compromised	Desirable - not required for mission success, but offers moderate science or implementation benefits; if technology is available, would almost certainly be implemented in mission	Minor science impact or implementation improvements; if technology is available would be considered for implementation in mission	No science impact or implementation improvement; even if available, technology would not be implemented in mission
Urgency	5	4	20	Given anticipated complexity and "length" of gap (informed by relevant ongoing efforts), assessed against the time available until anticipated launch and/or other schedule drivers, how urgently does the gap need to be addressed?	Estimated schedule margin of 0% or less (i.e., negative)	Estimated schedule margin is greater than 0% and less than or equal to 20%	Estimated schedule margin is greater than 20% and less than or equal to 40%	Estimated schedule margin is greater than 40% and less than or equal to 60%	Estimated schedule margin is greater than 60%
Scope of Applicability	2	4	8	How cross-cutting is the technology? How many Astrophysics programs and/or mission concepts (including Explorers and Probes) could it benefit?	Applies to more than one high-priority strategic Astrophysics mission concepts	Applies to one high-priority strategic Astrophysics mission concept and one or more other strategic mission concepts	Applies to more than one strategic Astrophysics mission concept	Applies to just one strategic Astrophysics mission concept and at least one non-strategic Astrophysics mission (e.g., Explorers, Probes, etc.)	Applies to only one strategic Astrophysics mission, or one or more non-strategic missions

POs Annual Report Contents Moved into ABTR and Websites

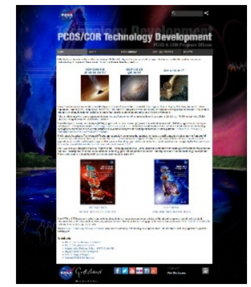
Was three reports annually
(with websites in support role)



Will be:

One report biennially starting 2019
(*cover mockup shown*)

Websites & Database playing major role

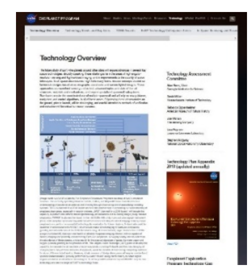


PCOS/COR technology

apd440.gsfc.nasa.gov/technology

AstroTech searchable database for PCOS, COR, and ExEP

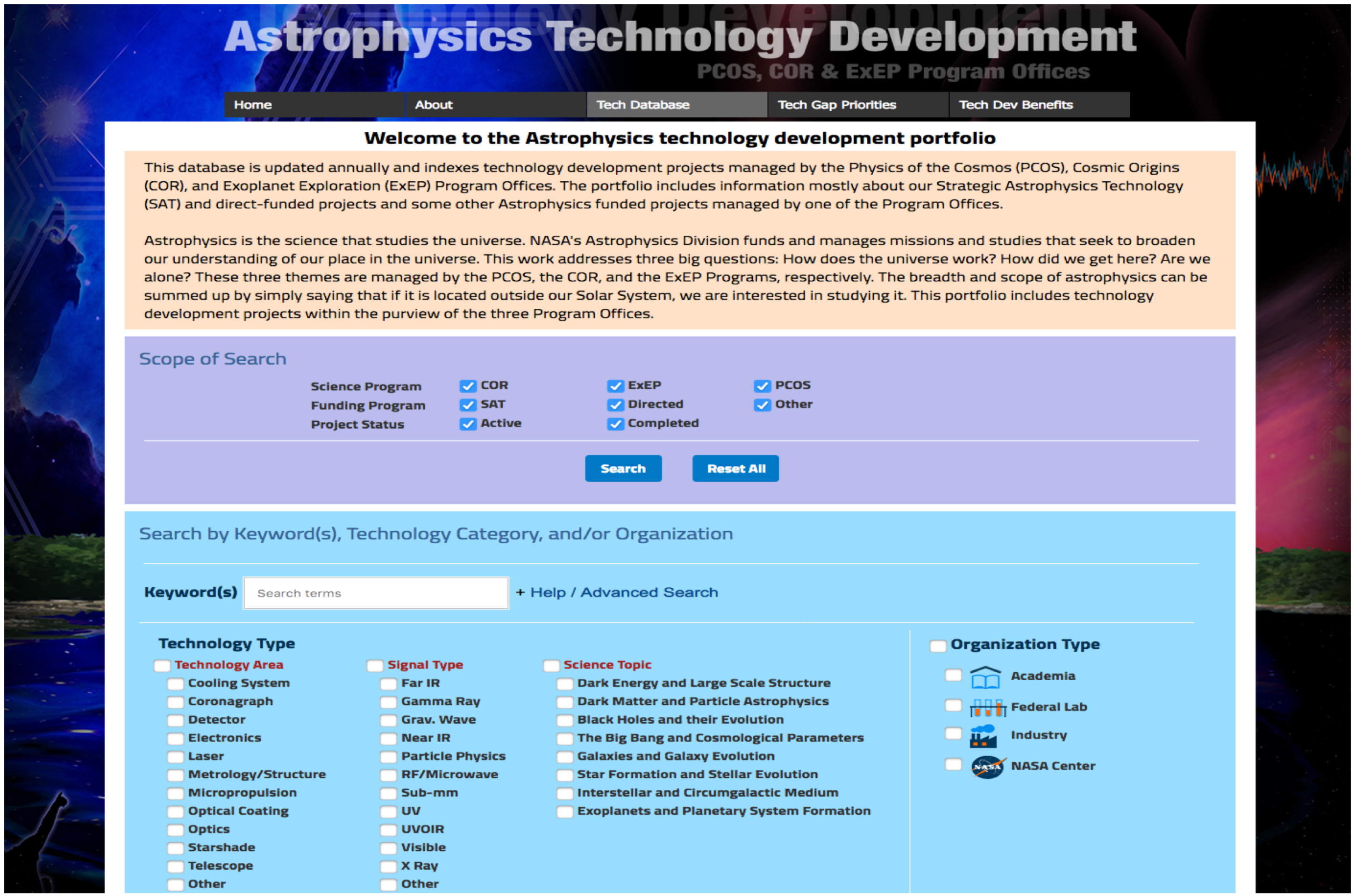
www.astrostrategictech.us/



ExEP technology

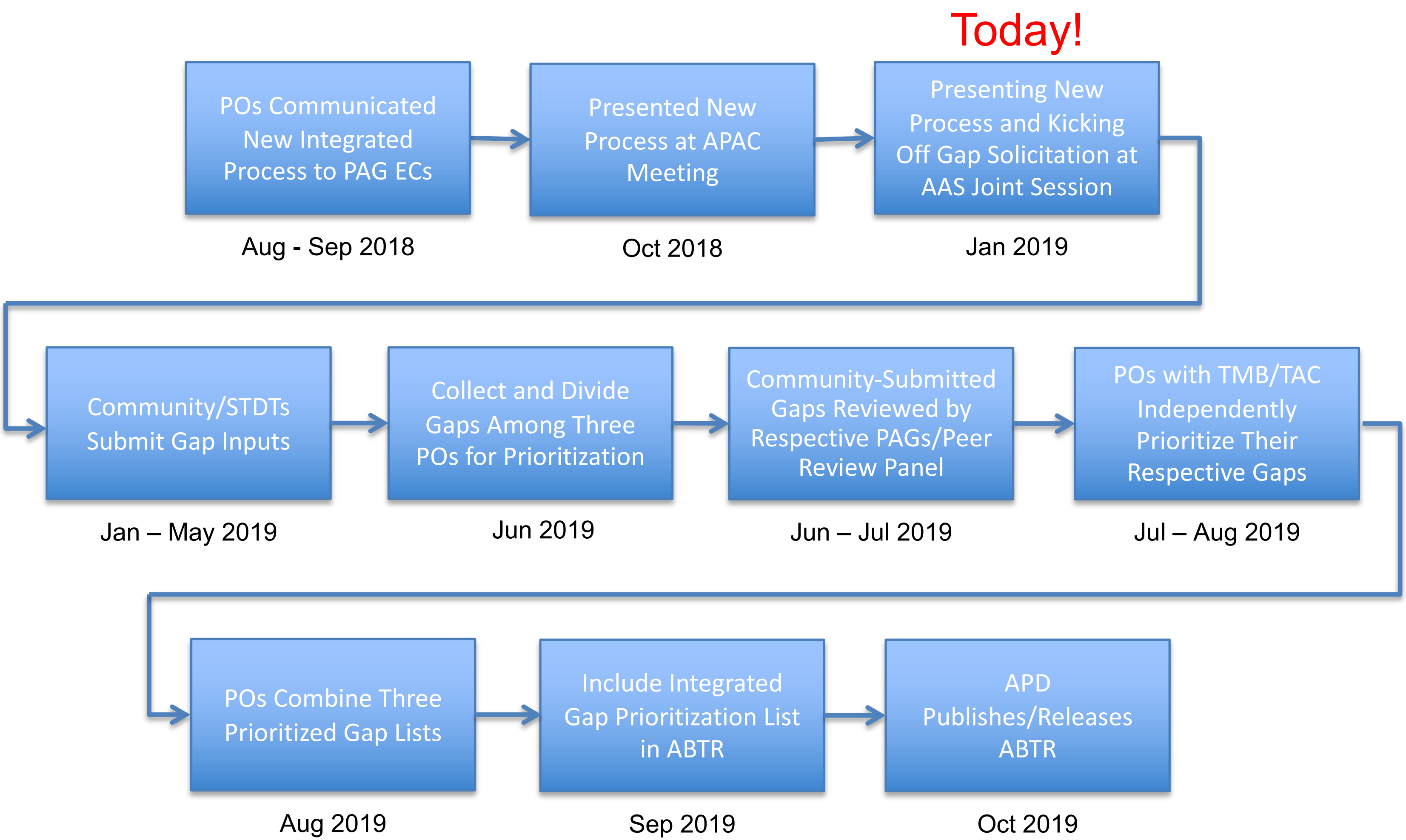
exoplanets.nasa.gov/exep/technology

Astrophysics Strategic Technology Development Database



Access to project description, abstract, reports, etc. of past and current strategic technology development investments across PCOS, COR, and ExEP through searchable database (http://www.AstroStrategicTech.us/)

Schedule for New Joint Process



SAT Proposal Call Continues Annually and Is also Integrated

- Strategic Astrophysics Technology (SAT, element D8 of Research Opportunity in Earth and Space Sciences, ROSES) will continue its annual solicitation cycle
- The SAT solicitation is no longer divided into three science elements; Technology development for PCOS (TPCOS), Technology Development for COR (TCOR) and Technology Development for Exoplanet Missions (TDEM)
- The single SAT solicitation addresses a range of scientific interest across Astrophysics

Takeaways

- APD has integrated and streamlined its strategic technology gap solicitation, prioritization, and reporting to better serve the astrophysics community
- A single, high-level, Astrophysics Biennial Technology Report (ABTR) will be published every other year starting in 2019
- Full details of the three Programs' technology maturation progress is now available, via a searchable database on the POs' websites
- Make your voice heard by submitting strategic technology gaps now through June 1, 2019 for prioritization this year
- Enable the future of astrophysics by submitting SAT proposals: mandatory NOIs due 2/27/2019, proposals due 3/29/2019 (these are the new dates adjusted as a result of the partial government shutdown)

Points of Contact

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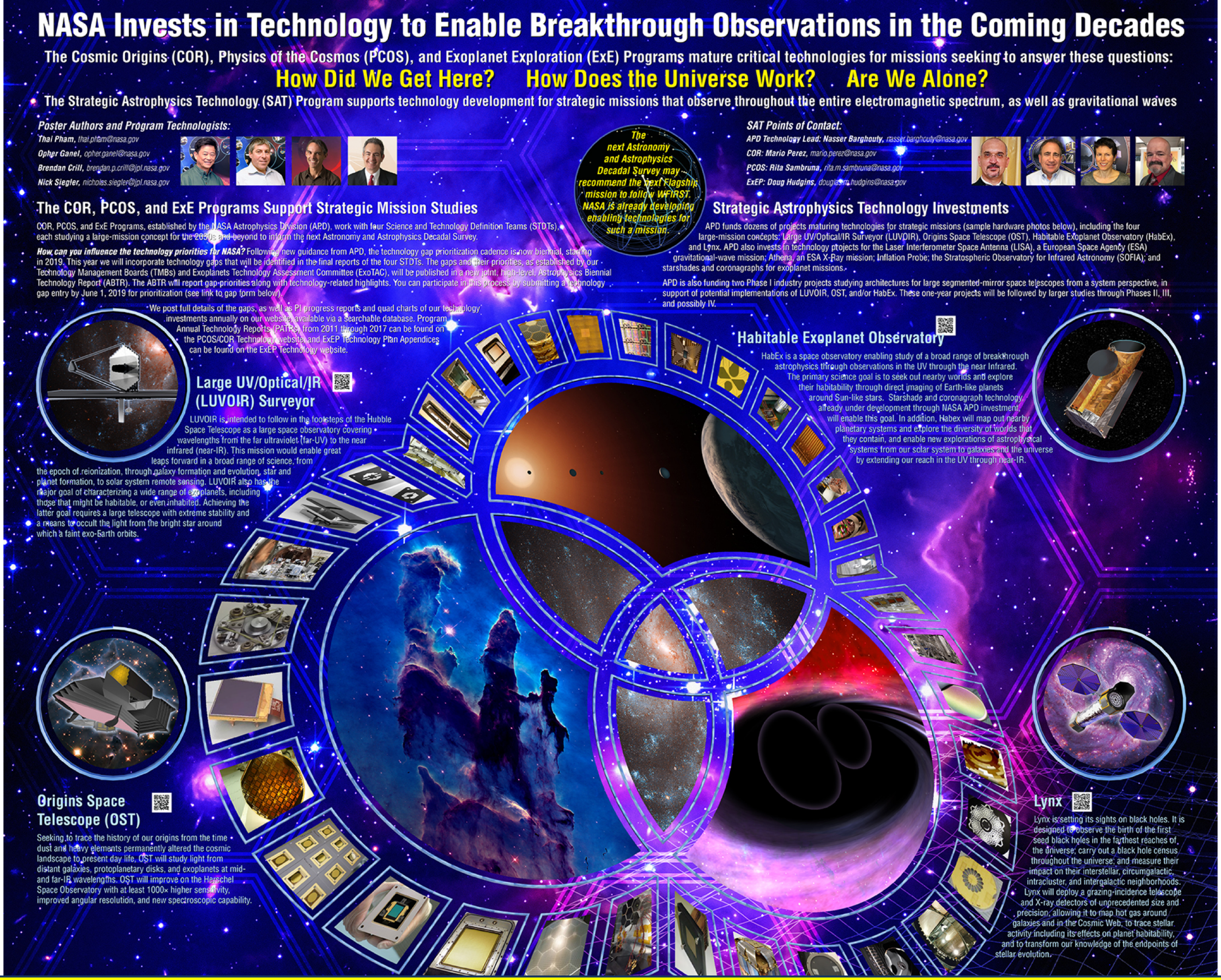
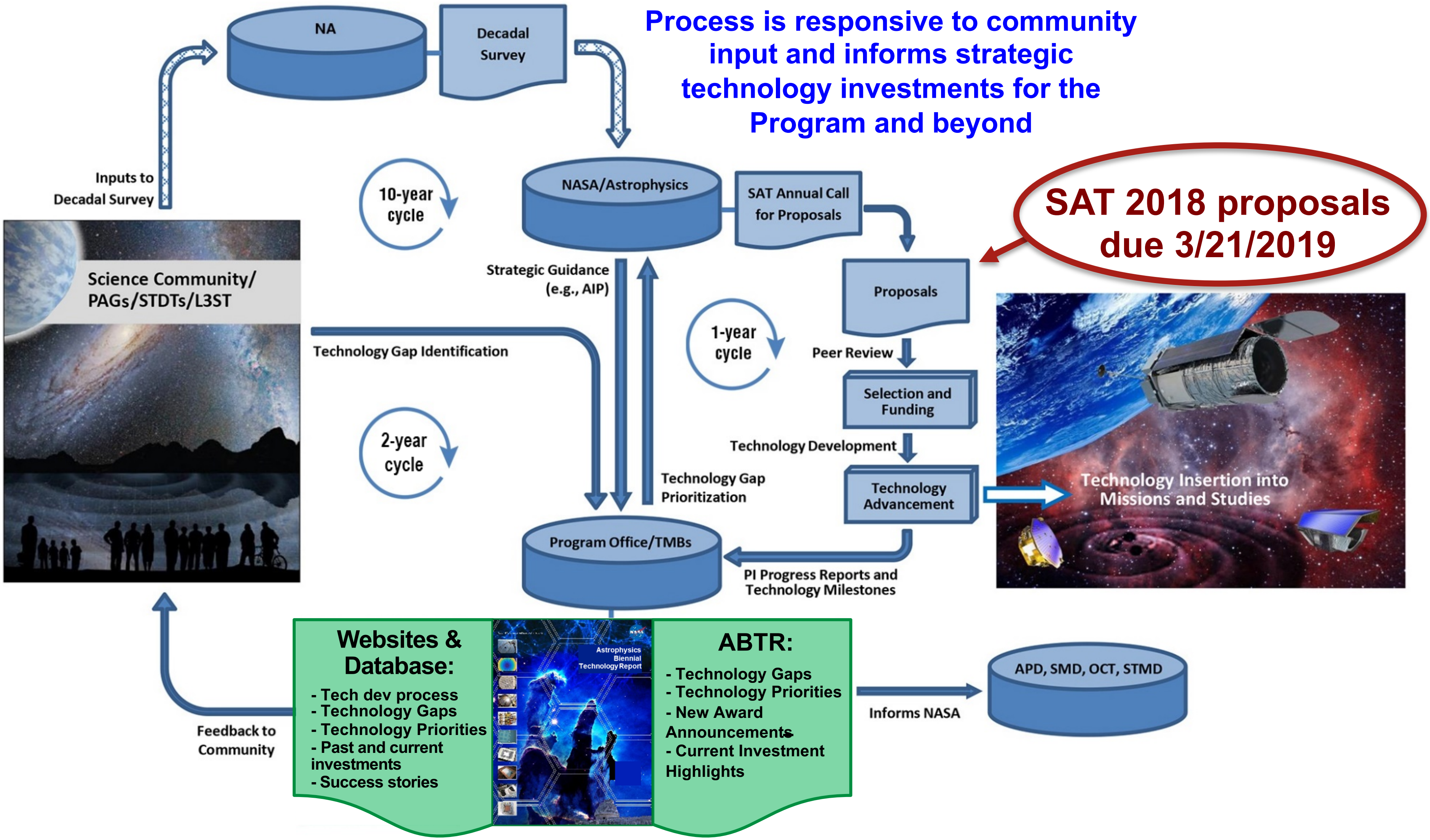


Thank you for your attention

Drop by our poster session on Wed

Backup

Strategic Technology Development Process



Astrophysics Funds All Levels of Technology Development

NASA's Astrophysics Division funds the development of technology at all levels of maturity

- **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 3 up to 9). Suborbital investigations (balloons, sounding rockets) are encouraged
- **Strategic Astrophysics Technology (SAT) program** matures key technologies that address the needs of a specific future mission, taking them from proof of concept through component/breadboard validation in relevant environment (TRL 3 through 5)
- **Flight projects** address final maturation stages (TRL 6 to 9) proving the technology's flight-worthiness for a mission-specific application

Technology Gap Input Form

Gap input form can be downloaded from https://apd440.gsfc.nasa.gov/technology/gap_form.docx

Astrophysics Technology Capability 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** ☐ **OST** ☐ **SOFIA** ☐ **IP** ☐ **BH Mapper** ☐ **Cosmic Dawn Mapper**
☐ **Exo-Earth Mapper** ☐ **GW Mapper** ☐ **Other:** ____________________

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

Assessment of the current State-of-the-Art (SOTA) and references justifying TRLs quoted at right (100 – 150 words):	Current TRL of SOTA:	
	Current TRL of Full Solution:	

Technical Goals and Objectives to Fill the Capability Gap:

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

Applications and Potential Relevant Missions for Astrophysics Division:

Urgency (time to estimated launch or other schedule driver vs. estimated complexity – i.e. time and cost to close the gap):

2017 PCOS Prioritization Criteria

#	Criterion	Weight	Max Score	Max Weighted Score	General Description/Question	4	3	2	1	0
1	Strategic Alignment	10	4	40	How well does the technology align with PCOS science and programmatic priorities of current programmatic guidance (i.e., AIP, Roadmap, NWNH)?	Technology enables PCOS-relevant science within mission concept receiving highest current programmatic consideration	Technology enables PCOS-relevant science within mission concept receiving mid to high current programmatic consideration in AIP or Roadmap	Technology enables PCOS-relevant science within mission concept receiving low current programmatic consideration in AIP or Roadmap	Technology enables PCOS-relevant science within mission concept not considered in AIP or Roadmap, but positively addressed in NWNH	Technology does not enable PCOS-relevant science within any mission concept considered by current programmatic guidance
2	Benefits and Impacts	8	4	32	How much impact does the technology have on PCOS-relevant science in applicable mission(s)? To what degree does the technology enable and/or enhance achievable science objectives, reduce cost, and/or reduce mission risks?	Critical and key enabling technology; required to meet PCOS-science-relevant mission concept objectives; without this technology mission would not launch or PCOS science return would be significantly impaired	Highly desirable; not mission-critical to PCOS-science-relevant objectives, but significantly enhances PCOS science capability, reduces critical resources needed, and/or reduces mission risks; without it, missions may launch, but PCOS science return would be compromised	Desirable - not required for PCOS-relevant mission success, but offers moderate PCOS-relevant science or implementation benefits; if technology is available, would almost certainly be implemented in missions for PCOS purposes	Minor PCOS-relevant science impact or implementation improvements; if technology is available would be considered for implementation in missions for PCOS purposes	No PCOS-relevant science impact or implementation improvement; even if available, technology would not be implemented in missions for PCOS purposes
3	Scope of Applicability	3	4	12	How cross-cutting is the technology? How many Astrophysics programs and/or mission concepts (including Explorers and Probes) could it benefit?	Applies widely to PCOS mission concepts and both COR <u>and</u> ExoPlanet mission concepts	Applies widely to PCOS mission concepts and either COR <u>or</u> ExoPlanet mission concepts	Applies widely to PCOS mission concepts	Applies to a single PCOS mission concept	No known applicable PCOS mission concept
4	Urgency	4	4	16	When are launches and/or other schedule drivers of missions enhanced or enabled by this technology anticipated?	Launch anticipated in next 4-8 years (2021-2025) or other schedule driver requires progress in 2-3 years (2019-2020)	Launch anticipated in next 9-13 years (2026-2030) or other schedule driver requires progress in 4-8 years (2021-2025)	Launch anticipated in next 14-18 years (2031-2035)	Launch anticipated in next 19-23 years (2036-2040)	Launch anticipated in 24 or more years (2041 or later)

2017 COR Prioritization Criteria

#	Criterion	Weight	Max Score	Max Weighted Score	General Description/Question	4	3	2	1	0
1	Strategic Alignment	10	4	40	How well does the technology align with COR science and programmatic priorities of current programmatic guidance (i.e., AIP, Roadmap, NWNH)?	Technology enables COR-relevant science within mission concept receiving highest current programmatic consideration	Technology enables COR-relevant science within mission concept receiving mid to high current programmatic consideration in AIP or Roadmap	Technology enables COR-relevant science within mission concept receiving low current programmatic consideration in AIP or Roadmap	Technology enables COR-relevant science within mission concept not considered in AIP or Roadmap, but positively addressed in NWNH	Technology does not enable COR-relevant science within any mission concept considered by current programmatic guidance
2	Benefits and Impacts	8	4	32	How much impact does the technology have on COR-relevant science in applicable mission(s)? To what degree does the technology enable and/or enhance achievable science objectives, reduce cost, and/or reduce mission risks?	Critical and key enabling technology; required to meet COR-science-relevant mission concept objectives; without this technology mission would not launch or COR science return would be significantly impaired	Highly desirable; not mission-critical to COR-science-relevant objectives, but significantly enhances COR science capability, reduces critical resources needed, and/or reduces mission risks; without it, missions may launch, but COR science return would be compromised	Desirable - not required for COR-relevant mission success, but offers moderate COR-relevant science or implementation benefits; if technology is available, would almost certainly be implemented in missions for COR purposes	Minor COR-relevant science impact or implementation improvements; if technology is available would be considered for implementation in missions for COR purposes	No COR-relevant science impact or implementation improvement; even if available, technology would not be implemented in missions for COR purposes
3	Scope of Applicability	3	4	12	How cross-cutting is the technology? How many Astrophysics programs and/or mission concepts (including Explorers and Probes) could it benefit?	Applies widely to COR mission concepts and both PCOS <u>and</u> ExoPlanet mission concepts	Applies widely to COR mission concepts and either PCOS <u>or</u> ExoPlanet mission concepts	Applies widely to COR mission concepts	Applies to a single COR mission concept	No known applicable COR mission concept
4	Urgency	4	4	16	When are launches and/or other schedule drivers of missions enhanced or enabled by this technology anticipated?	Launch anticipated in next 4-8 years (2021-2025) or other schedule driver requires progress in 2-3 years (2019-2020)	Launch anticipated in next 9-13 years (2026-2030) or other schedule driver requires progress in 4-8 years (2021-2025)	Launch anticipated in next 14-18 years (2031-2035)	Launch anticipated in next 19-23 years (2036-2040)	Launch anticipated in 24 or more years (2041 or later)

ExEP Prioritization Criteria from 2017

Impact: (weight: 10)	4: Critical strategic technology for the New Worlds Technology Development Program envisioned in New Words, New Horizons (2010 Decadal Survey) and in the NASA Astrophysics Implementation Plan; without this technology, the mission would not launch
	3: Highly desirable - not mission-critical, but provides major benefits in enhanced science capability, reduced critical resources need, and/or reduced mission risks; without it, missions may launch, but science or implementation would be compromised
	2: Desirable - not required for mission success, but offers significant science or implementation benefits; if technology is available, would almost certainly be implemented in missions
	1: Minor science impact or implementation improvements; if technology is available would be considered for implementation in missions

Urgency (weight: 10)	4: Advances technology or reduces risk needed for missions currently in Pre-Formulation or formulation.
	3: In time to inform the 2020 Decadal Survey; not necessarily at some TRL but reduced risk.
	2: Earliest projected launch date < 15 yr (< 2033)
	1: Earliest projected launch date > 15 yr (> 2033)

Trend (weight: 5)	4: (a) no ongoing current efforts, or (b) little or no funding allocated
	3: (a) others are working towards it but little results or their performance goals are very far from the need, (b) funding unclear, or (c) time frame not clear
	2: (a) others are working towards it with encouraging results or their performance goals will fall short from the need, (b) funding may be unclear, or (c) time frame not clear
	1: (a) others are actively working towards it with encouraging results or their performance goals are close to need, (b) it's sufficiently funded, and (c) time frame clear and on time

2017 PCOS Tech Gap Prioritization

	PCOS Technology Capability Gaps	Science	Tech	Funded
1	Highly stable low-stray-light telescope	GW	Telescope	✓
	Low-mass, long-term-stability optical bench	GW	Optical Bench	
	Precision Microthrusters	GW	Propulsion	✓
	High-power, narrow-line-width laser sources	GW	Laser	✓
	Phase measurement subsystem (PMS)	GW	Electronics	✓
	Large-format, high-spectral-resolution, small-pixel X-ray focal plane arrays	X ray	Detector	✓
	Fast, low-noise, megapixel X-ray imaging arrays with moderate spectral resolution	X ray	Detector	✓
	High-efficiency X-ray grating arrays for high-resolution spectroscopy	X ray	Optics	✓
	High-resolution, large-area, lightweight X-ray optics	X ray	Optics	✓
	Non-deforming X-ray reflective coatings	X ray	Coating	✓
	Long-wavelength-blocking filters (free standing) for X-ray micro-calorimeters	X ray	Optics	
2	Non-contact charge control for Gravitational Reference Sensors (GRS)	GW	Electronics	✓
	Advanced millimeter-wave focal plane arrays for CMB polarimetry	IP	Detector	✓
	Polarization-preserving millimeter-wave optical elements	IP	Optics	
	High-efficiency, low cost cooling systems for temperatures near 100 mK	IP, X ray	Cooler	✓
	Rapid readout electronics for X-ray detectors	X ray	Electronics	✓
	Optical-blocking filters (OBF)	X ray	Optics	✓
3	Gravitational reference sensor (GRS)	GW	Detector	
	Very-wide-field focusing instrument for time-domain X-ray astronomy	X ray	Optics	
	Ultra-high-resolution focusing X-ray observatory telescope	X ray	Telescope	
	Advancement of X-ray polarimeter sensitivity using negative ion gas	X ray	Detector	
4	Low-power, low-resolution continuous GSa/s direct RF digitizer	CR	Detector	
	Tileable, 2-D Proportional Counter Arrays	Gamma ray	Detector	
	High-performance gamma-ray telescope	Gamma ray	Telescope	
	Lattice optical clock for Solar Time Delay mission and other applications	STD	Electronics	
	Fast, few-photon UV detectors	UHECR	Detector	
	Lightweight, large-area reflective optics	UHECR	Optics	
	Low-power time-sampling readout	UHECR	Electronics	
	Low-power comparators and logic arrays	UHECR	Detector	

Gaps within a specific tier have equal priority. ✓ is PCOS funding. ✓ is COR funding.

2017 COR Tech Gap Prioritization

	COR Technology Capability Gaps	Science	Tech	Funded
1	Heterodyne FIR detector arrays and related technologies	Far IR	Detector	✓
	Cryogenic readouts for large-format Far-IR detectors	Far IR	Electronics	
	Warm readout electronics for large-format Far-IR detectors	Far IR	Electronics	
	Large Cryogenic Optics for the Far IR	Far IR	Optics	✓
	Large-format, low-noise and ultralow noise far-infrared (FIR) direct detectors	Far IR	Detector	✓
	High-performance, sub-Kelvin coolers	Far IR, X-ray	Cooler	✓
	Large-format, High-Dynamic-Range UV Detectors	UV, FUV	Detector	✓
	High Reflectivity Broadband FUV-to-NIR Mirror Coatings	UVOIR	Coating	✓
2	Lightweight, large-aperture, high-performance telescope mirror systems for Far-IR	Far IR	Optics	✓
	Compact, Integrated Spectrometers for 100 to 1000 µm	Far IR	Detector	
	Advanced Cryocoolers	Far IR, X-ray	Cooler	
	Mid-IR detectors	Mid IR	Detector	
	Cryogenic deformable mirror	Mid IR	Optics	
	High-efficiency UV multi-object spectrometers	UV	Detector	✓
	Lightweight, large-aperture, high-performance telescope mirror systems for UVOIR	UVOIR	Optics	✓
	High-performance spectral dispersion component/device	UVOIR, Far IR	Optics	
	Advanced Adaptive Optics	UVOIR, HabEx	Optics	✓
	Band-shaping and dichroic filters for the UV/Vis	UV, VIS	Optics	
3	Wide-bandwidth, high-spectral-dynamic-range receiving system	Cosmic Dawn	Detector	
	High-precision low-frequency radio spectrometers and interferometers	Cosmic Dawn	Detector	
	FIR interferometry	Far IR	Detector	
	Mid-IR coronagraph optics and architecture	Mid IR	Optics	
	UV/Opt/NIR Tunable Narrow-Band Filters	UVOIR	Optics	
	Ultra-Stable Opto-Mechanical Systems Architecture	UVOIR, HabEx	Telescope	✓
	Segment Phasing and Control	UVOIR, HabEx	Telescope	✓
	Dynamic Isolation Systems	UVOIR, HabEx	Telescope	✓
	Segmented-Aperture Coronagraph Architecture	UVOIR, HabEx	Optics	✓
	High-contrast Imaging Post-Processing	UVOIR, HabEx	Electronics	✓
	Mirror Segments Systems	UVOIR, HabEx	Optics	✓

Gaps within a specific tier have equal priority. ✓ is COR funding. ✓ is Exoplanet funding.

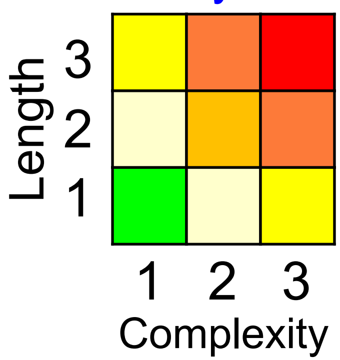
2017 ExEP Technology Prioritization

ID	Technology Title	Impact	Urgency	Trend	Total
	weight:	10	10	5	Score
CG-2	Coronagraph Architecture	4	4	2	**90**
S-2	Starlight Suppression and Model Validation	4	4	2	**90**
S-1	Controlling Scattered Sunlight	4	4	2	**90**
S-3	Lateral Formation Sensing	4	4	2	**90**
S-5	Petal Positioning Accuracy and Opaque Structure	4	4	2	**90**
S-4	Petal Shape and Stability	4	4	2	**90**
CG-3	Deformable Mirrors	4	4	2	**90**
CG-1	Large Aperture Primary Mirrors	4	3	3	**85**
CG-6	Mirror Segment Phasing	4	3	3	**85**
CG-7	Telescope Vibration Sense/Control or Reduction	4	3	3	**85**
CG-9	Ultra-Low Noise Near-Infrared Detectors	4	3	3	**85**
CG-5	Wavefront Sensing and Control	4	3	2	**80**
CG-8	Ultra-Low Noise Visible Detectors	4	3	2	**80**
M-4	Ultra-Stable Mid-IR detector	3	3	4	**80**
M-3	Astrometry	3	3	3	**75**
CG-4	Data Post-Processing Algorithms and Techniques	4	2	2	**70**
CG-10	Mirror Coatings for UV/NIR/Vis	3	3	2	**70**
M-2	Space-based Laser Frequency Combs	3	3	2	**70**
CG-13	Ultra Low-noise Mid-IR detectors	2	3	4	**70**
M-1	Extreme Precision Ground-based Radial Velocity	2	3	3	**65**
CG-14	Mid-IR Large Aperture Telescopes	2	3	3	**65**
CG-15	Mid-IR Coronagraph Optics and Architecture	2	3	3	**65**
CG-16	Cryogenic Deformable mirror	2	3	3	**65**
CG-12	Ultra-Low Noise UV Detectors	2	3	2	**60**

Urgency Criterion - Draft

- ***Urgency***: **Given the anticipated difficulty of maturing from current TRL of a full solution to TRL 6 (informed by all relevant ongoing efforts that are known), assessed against the time available until anticipated launch and/or other schedule drivers, how urgently does the gap need to be addressed?**
- **Proposed process:**
  - *Thinking of technology development as a bridge to get us from where we are (state of the art) to where we need to go (required performance), get input from PAGs (with TMB review) on gap complexity or "breadth" and on gap "length"*
  - *Based on complexity and length scores, and current full-solution TRL, estimate likely duration needed to get to TRL 6, thinking of this as the "bridge area" needed to close the gap*
  - *Calculate margin between likely development duration and available time and compare to criterion values*
- **Complexity or "breadth" of gap:**
  1. *Single technology (e.g., EUV-reflective coating)*
  2. *System of technologies (e.g., cryogenic detector and front-end electronics)*
  3. *System of technology systems (e.g., ultra-stable structure for large space telescope)*
- **"Length" to bridge gap between state-of-the-art and desired TRL:**
  1. *Straightforward (e.g., port existing X-ray event ID algorithm to FPGA implementation)*
  2. *Stretch (e.g., broadband far-IR heterodyne detectors)*
  3. *Extreme stretch (e.g., ultra-stable structure for large space telescope)*

Difficulty Matrix



- **Estimated duration (proposed formula):**
  - *Duration ≈ Length × Complexity × 1.5 years*
  - *Note that the formula doesn't have to be exactly right, just plausible and applied uniformly*
- **Margin:**
  - *Divide available time by estimated duration and subtract 1 to obtain percent schedule margin*
  - *To obtain Urgency score, compare the margin to the criterion values in the matrix on a previous slide*

Available Times for Tech Dev

- Assumed available times for technology development for current strategic missions is up to 10 years before launch to represent approximate time to Preliminary Design Review (PDR) when new technologies need to be at TRL 6:
  - HabEx, OST, LUVOIR, and Lynx (2035 launch, 2025 end of tech dev)
  - SOFIA (score of 2)
  - Inflation Probe (2030 launch, 2020 end of tech dev)
  - Gravitational Wave Mapper, Cosmic Dawn Mapper, ExoEarth Mapper, Black Hole Mapper (2085 launch, 2075 end of tech dev)

SAT Stats

Solicitation Year	SAT Proposals		Selection Rate
	Submitted	Awarded	
2009	34	7	21%
2010	57	17	30%
2011	50	10	20%
2012	40	9	23%
2013	18	10	56%
2014	28	11	39%
2015	29	7	24%
2016	30	9	30%
2017	25	11	44%
Total to Date	311	91	29%

Solicitation Year	TDEM SAT Proposals		Selection Rate
	Submitted	Awarded	
2009	34	7	21%
2010	22	9	41%
2011	Not solicited	NA	NA
2012	17	3	18%
2013	10	4	40%
2014	8	3	38%
2015	7	1	14%
2016	6	3	50%
2017	10	3	30%
Total to Date	114	33	29%

Solicitation Year	PCOS SAT Proposals		Selection Rate
	Submitted	Awarded	
2010	21	5	24%
2011	26	5	19%
2012	10	3	30%
2013	8	6	75%
2014	6	3	50%
2015	10	4	40%
2016	5	2	40%
2017	4	3	75%
Total to Date	90	31	34%

Solicitation Year	COR SAT Proposals		Selection Rate
	Submitted	Awarded	
2010	14	3	21%
2011	24	5	21%
2012	13	3	23%
2013	Not Solicited	NA	NA
2014	14	5	36%
2015	12	2	17%
2016	19	4	21%
2017	11	5	45%
Total to Date	107	27	25%