Technology Management and Resources Available to SAT Awardees

SAT 2018 Pre-proposal Briefing

February 19, 2019

Brendan Crill, Brendan.p.crill@jpl.nasa.gov, 818 354-5416

Thai Pham, thai.pham@nasa.gov, 301 286-4809

Presentation Topics

- **NSSC Annual Reporting Requirements**
- **Program Office Oversight Reporting Requirements**
  - Exoplanet Exploration Program (ExEP)
    - Program facility resources available to PIs
  - Physics of the Cosmos and Cosmic Origins (PCOS & COR)

NSSC Annual Reporting Requirements

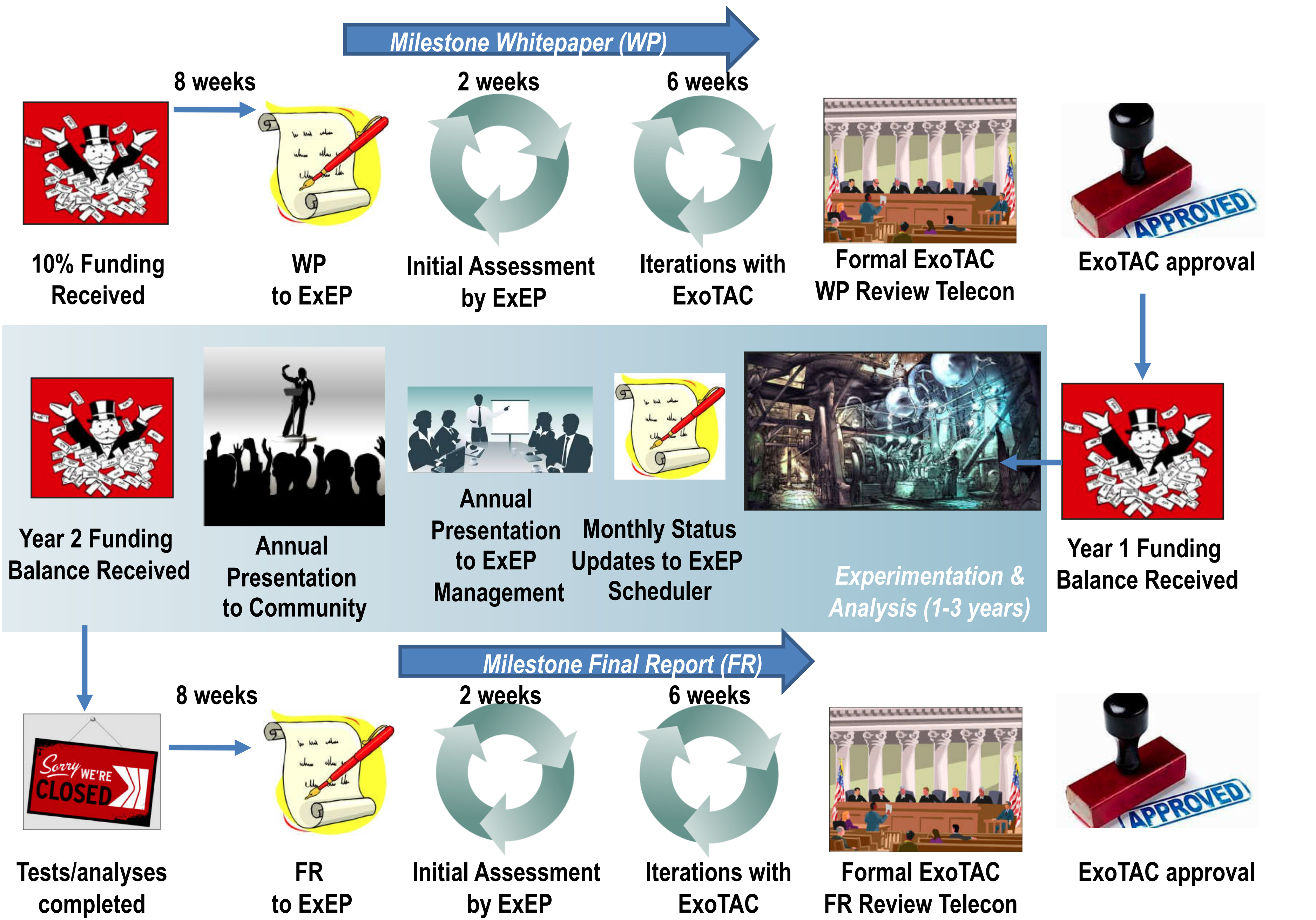
- **NASA Shared Services Center (NSSC) provides support for NASA research, science, and education communities in the award and administration of research and research-related grants and cooperative agreements.**
- **An annual progress report must be submitted to the respective Program Officer and NSSC before funds for the following year of the award are disbursed.**
  - You will be informed which Program Officer your SAT is assigned to (Douglas Hudgins, Rita Sambruna, or Mario Perez)
- **The annual report shall contain detailed documentation of the progress toward the milestones identified in the proposal, a description of the plan forward, and its expected outcomes.**

Program Office Oversight Reporting Requirements for ExEP-Managed SAT Awards and ExEP Resources Available to SAT PIs

Brendan Crill
Deputy Program Chief Technologist
NASA Exoplanet Exploration Program (ExEP)
Jet Propulsion Laboratory/California Institute of Technology

https://exoplanets.nasa.gov/exep/technology

Strategic Astrophysics Technology – reporting for Exoplanet Exploration Program



ExEP Resources for TDEM PIs

- This presentation provides an overview of the ExEP resources located at JPL available to support a TDEM-18 proposal.

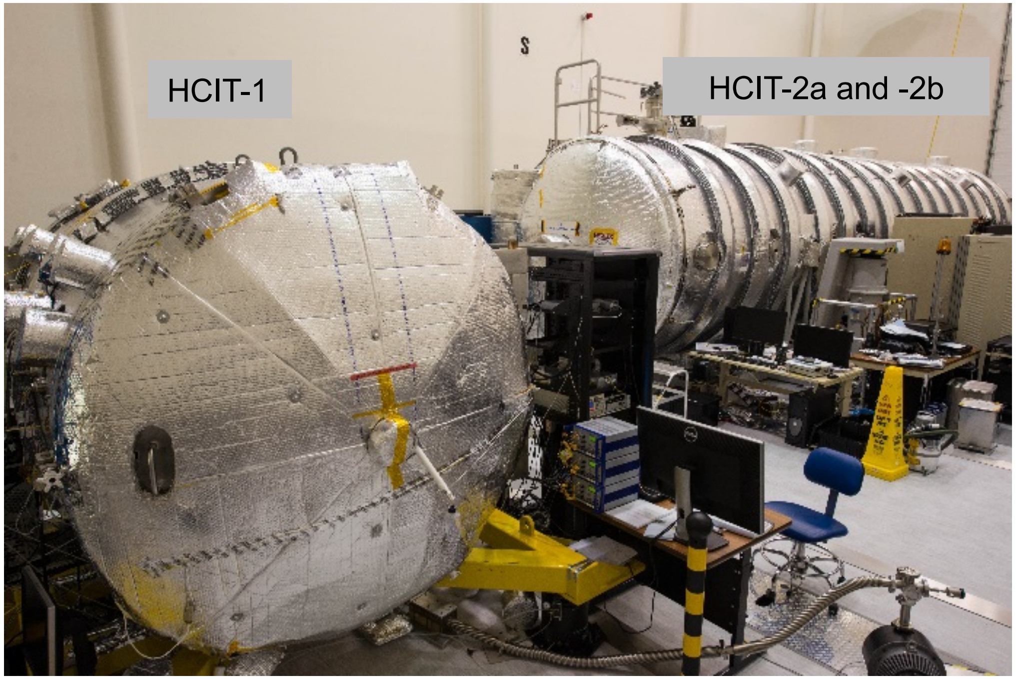
- The available resources, if appropriate for your needs, may help you more efficiently meet your milestone goals and reduce your proposal costs and schedule.

Unavailable Resources

- HCIT-1 (dedicated to WFIRST)

Available Resources

- HCIT-2a (Decadal Survey Testbed)
- HCIT-2b (General Purpose Coronagraph Testbed)
- Vacuum Surface Gauge
- Microdevices Laboratory (MDL)



Gaining Access to the ExEP Resources at JPL

How to Request Use of ExEP Resources at JPL

- **Submit preliminary Statement of Work (SOW) for use of ExEP resources to Brendan Crill no later than March 15, 2019.**
  - Follow SOW questionnaire on next page.

- **Schedule telecon with Brendan Crill between March 18 – 22, 2019 to discuss use of the resources of interest and to obtain costing guidelines.**
  - We will evaluate with the PI workforce, labor, and infrastructure access required across all received SOWs.

- **Brendan Crill will supply the proposal PI a Letter of Commitment for use of any ExEP resources.**
  - PIs are to include both the SOW and the Letter of Commitment in their proposal.
  - HCIT will provide workforce cost to set up testbeds; additional labor and unique procurements must be costed within the proposal.

SOW Questionnaire for Use of ExEP Resources

1. **Brief description of the proposed SAT**
2. **What resources are requested?**
3. **Milestone(s) to be accomplished and performance goals**
4. **Brief description of how the work will be conducted**
5. **Period(s) and preferred dates, if any, over which the resource is requested, stating whether in vacuum or air for testbeds. Include any time required for preparatory work.**
6. **A list of the personnel, expertise, and level of effort (if any) who will assist in the use of the resource.**
7. **Any anticipated changes to the resource needed to accommodate your demonstrations.**
8. **List of items needed for all testbed modifications. Identify items you will be procuring within your proposal's budget and provide approximate cost of needed items.**
   a. Otherwise, state that no additional procurements will be necessary for the use of the infrastructure under consideration.
9. **Provide any other relevant information or constraints.**

ExEP Technology Resources POC

For questions concerning use of ExEP technology resources or requests for more detail contact:

Dr. Brendan Crill

Jet Propulsion Laboratory

4800 Oak Grove Drive

Pasadena, CA 91109

Office: (818) 354-5416

Email: bcrill@jpl.nasa.gov

Program Office Oversight Reporting Requirements for PCOS/COR-Managed SAT Awards

Thai Pham
Program Technology Development Manager
Physics of the Cosmos & Cosmic Origins Program Offices
NASA/Goddard Space Flight Center

https://apd440.gsfc.nasa.gov/technology.html

PCOS/COR-Managed SAT Reporting Requirements

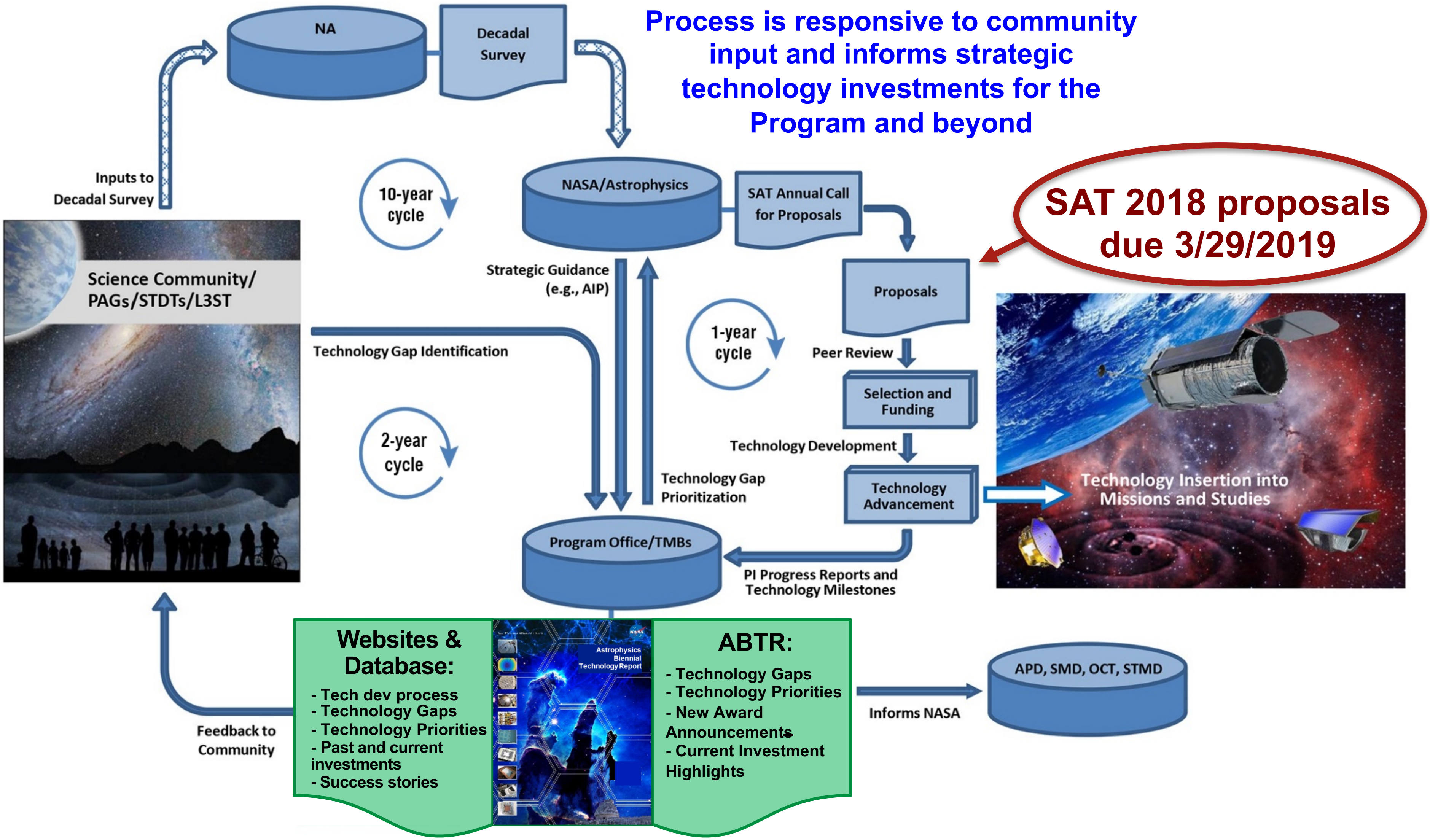
- **Written and oral status reports are required throughout the grant period of performance.**
  1. Kickoff/Annual presentation (Nov/Dec)
     - New PIs introduce development activities and present a work plan
     - Returning PIs report status, progress, and plan forward
  2. Bi-monthly progress reports
     - Brief technical and programmatic highlights
  3. Mid-year written status report (Jun)
     - Report includes status, progress, and future work
  4. Final report
     - Summarizes development activities and findings at the end of the grant
- **Mid-year and Final reports (Items 3 and 4 above) are posted on our publicly accessible Astrophysics technology database located at http://www.astrostrategictech.us/**
- **When TRL advancement is achieved, PI is asked to make a TRL advancement justification presentation to an independent board convened by the Program Office.**
- **PIs are assigned an eBooks account to facilitate report communication, deliverable submission, and archiving. Annual agency IT security training is required for access.**

Additional Info

Strategic Technology Development Process

Process is responsive to community input and informs strategic technology investments for the Program and beyond

SAT 2018 proposals due 3/29/2019



Astrophysics Funds All Levels of Technology Development

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

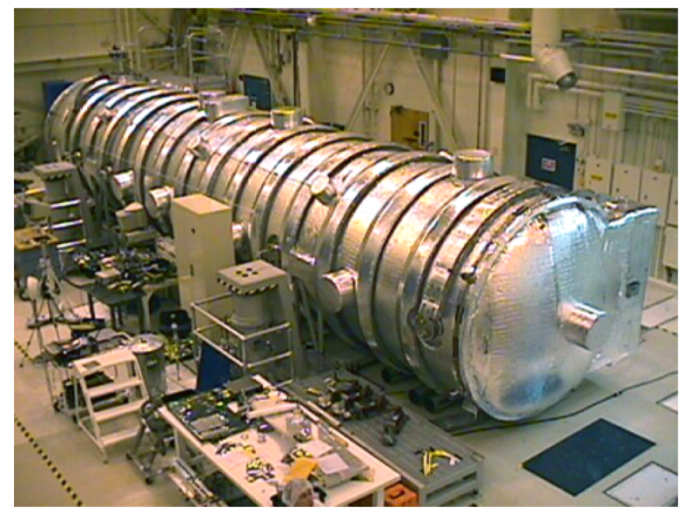
- **Astrophysics Research and Analysis (APRA) program** solicits basic research proposals relevant to NASA's astronomy and astrophysics programs, from basic principles through flight missions (Technology Readiness Level, TRL, 1 through 3 up to 9). Suborbital investigations (balloons, sounding rockets) 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

High Contrast Imaging Testbed (HCIT)

Test Facility

- Two vacuum chambers with 1 mTorr capability
- Seismically isolated, temperature-stabilized ~ 10 mK at RT.
- Narrow or broad band coronagraph system demos
  - Achieved $3x10^{-10}$ contrast (narrowband)
- Fiber/Pinhole “Star” Illumination
  - Monochromatic: 635, 785, 809, and 835 nm wavelengths
  - 2, 10, and 20% BW around 800 nm center
  - Medium and high power super-continuum sources
- CCD camera ($5e^-$), 13 μm pixels
- Complete computer control with data acquisition and storage
- Coronagraph model validation & error budget sensitivities
- Remote access through FTP site
- Wavefront control and speckle nulling available with Xinetics PMN deformable mirrors.
  - Format sizes: 32x32mm, 48x48, and 64x64 mm with 1 mm pitch and 500 nm stroke size.
  - Continuous fuse silica facesheet polished to λ/100 rms
  - Two-DM configurations available

HCIT-1
Single-testbed capacity (5’x8’)

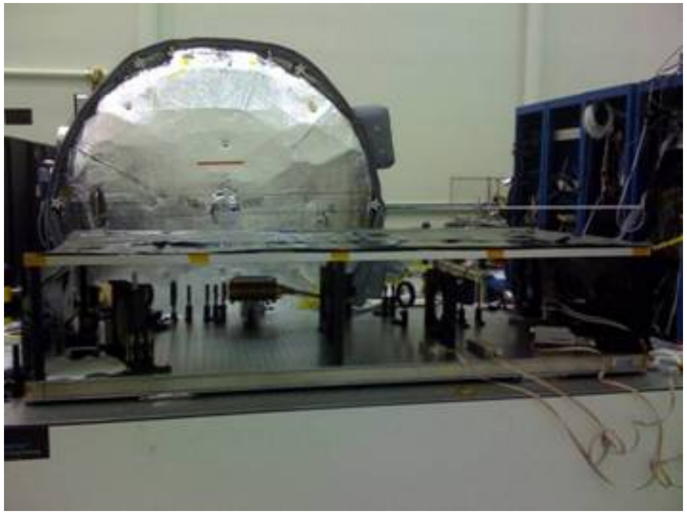


HCIT-2
Two-testbed capacity (6’x10’)

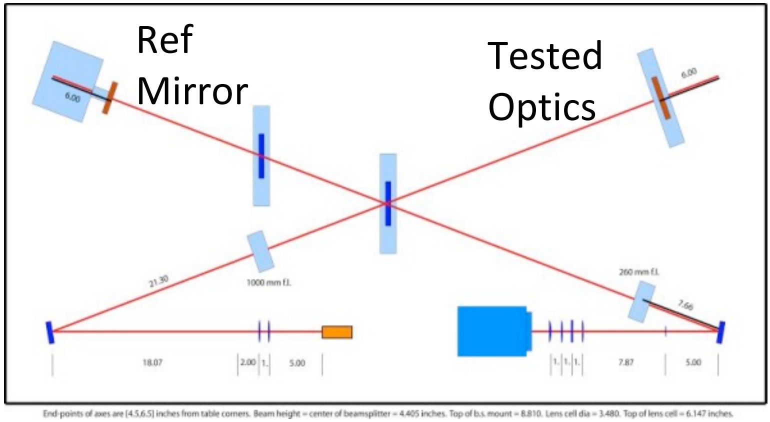
Vacuum Surface Gauge testbed

Purpose: Accurate surface error measurement and deformable mirror calibration.

- **Demonstrated optical surface measurement accuracy: ≤ 100 pm rms**
- **Customized Michelson interferometer set-up**
  - Reference mirror w/ absolute position feedback
  - Frequency stabilized laser source
- **Dedicated algorithms for wavefront extraction over > 10^6 pixels**



Vacuum Surface Gauge testbed



Surface Gauge optical layout

MicroDevices Laboratory (MDL)

Purpose: Precision sub-micron materials fabrication and characterization

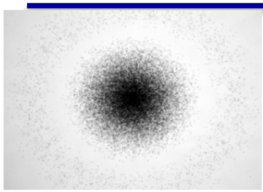


Figure 1. Microscope image (above) and AFM profile (below) of a micro dot patterned mask for JWST NIRCam coronagraph

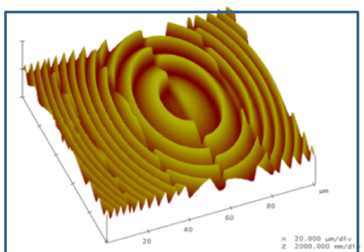
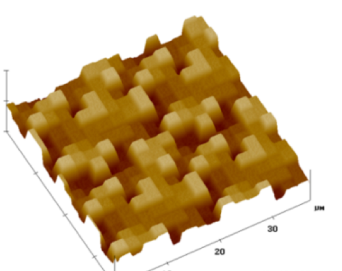


Figure 2. Diffractive optical devices



Advanced fabrication and characterization techniques

- Electron Beam Lithography
- Deep Reactive Ion Etching
- ICP Cryo Etching of Black Silicon microstructures

- Scanning Electron Microscopy
- Precision Optical Microscopy
- Atomic Force Microscopy
- 2D and 3D profilometry

Light suppression mask fabrication processes developed for:

- Micro dot patterned mask for JWST (Fig 1)
- Diffractive optical structures for spectrometer gratings and other computer generated holograms (Fig 2)
- Shaped pupil masks with fine structures and slits for transmission geometry (Fig 3)
- Shaped Pupil masks with black silicon structures in reflective aluminum background (Fig 4)
- LOWFS masks (Fig 5) incorporating a black silicon region (Fig 6) as well as shaped aperture through a silicon wafer
- Achromatic focal plane masks with deep diffractive structures (Fig 7)
- PIAACMC mask (Fig 8)
- Hybrid Lyot mask for WFIRST(Fig 9)
- Starshade mask for Princeton testbed (Fig 10)

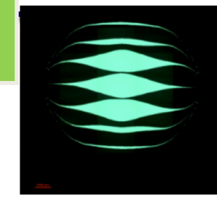


Figure 3. Transmissive slit SP mask

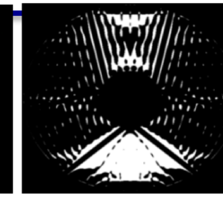


Figure 4. Reflective and absorptive SP mask

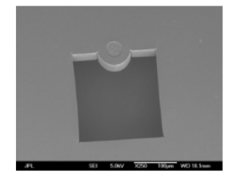


Figure 5. LOWFS mask

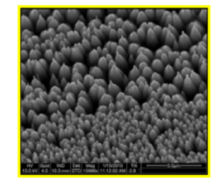
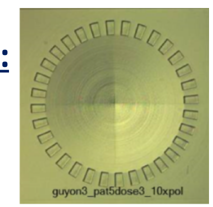


Figure 6. Black Si Microstructure



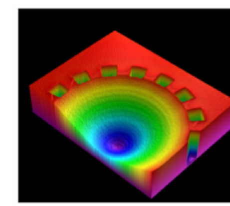


Figure 7 . Achromatic Focal Plane Masks (AFPM)

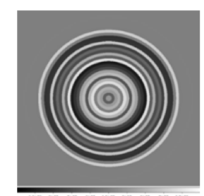


Figure 8 . PIAACMC mask

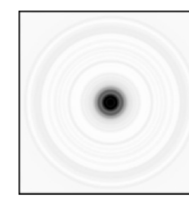


Figure 9 . Hybrid Lyot mask

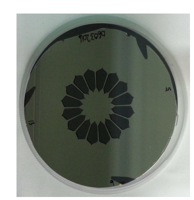


Figure 10 . Starshade mask

Current 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.

Current 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.

Current 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**

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%