

# Exoplanet Exploration Program Technology Update

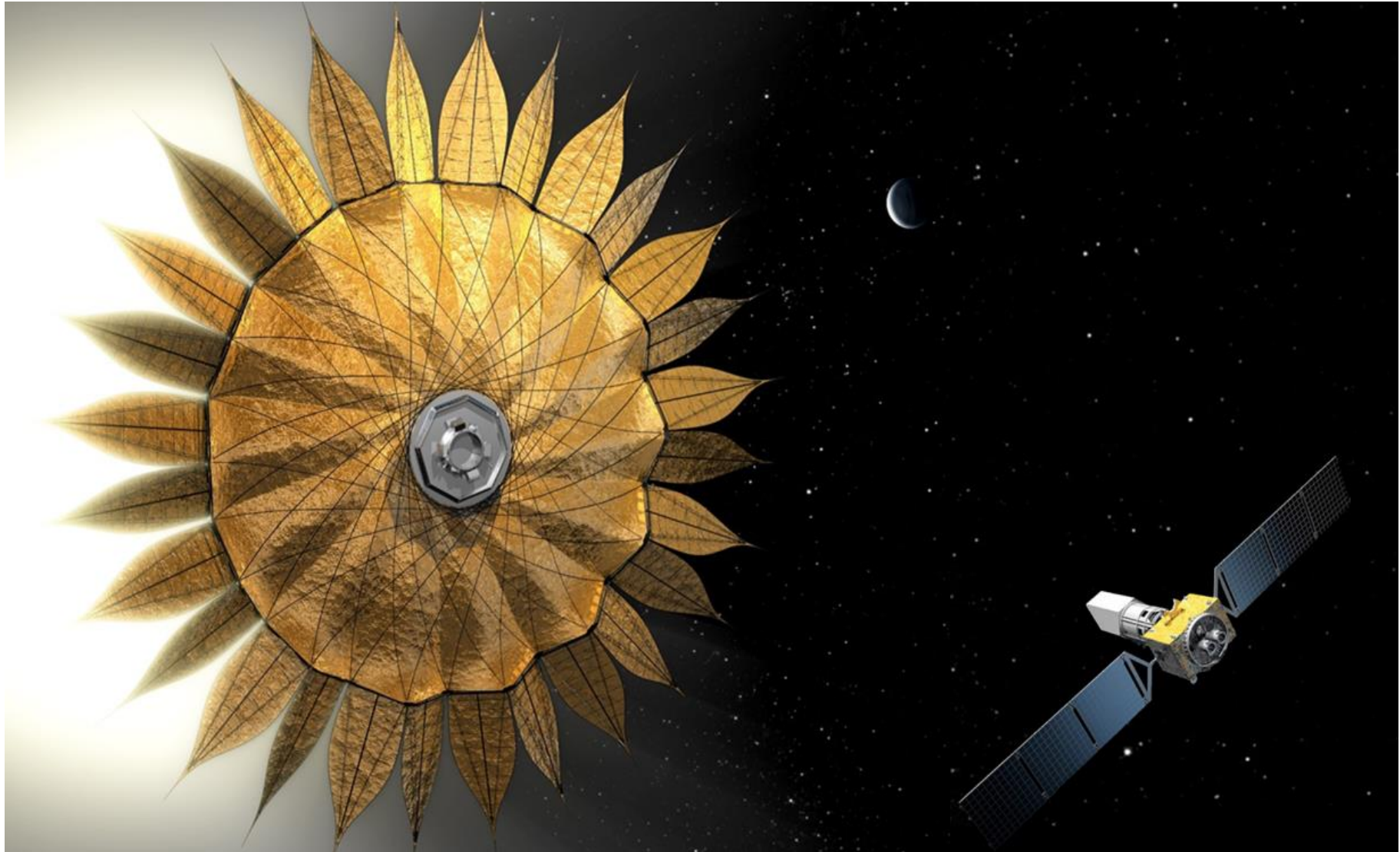
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**Exoplanet Exploration Program**  
**Jet Propulsion Laboratory / California Institute of Technology**

**ExoPAG 33**  
**January 2026**

*Image Credit:*  
NASA/JPL-Caltech/T. Pyle  
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# Starshade Technology Development Close-Out



# Starshade Technology Development Close-Out



- 15 of 15 milestones completed
- Starshade Technology Development Activity completed its work
- The five key technologies were all matured to TRL 5 for a 26-m starshade (baseline reference mission was the Roman Space Telescope)

- All of the development is directly applicable to a UV application for HWO, with only a ground UV demonstration needed to achieve TRL 5.
- The risk of achieving this was deemed low.

# 23 Active or Completed Exoplanet SATs in 2025



- **Low-Vibration Propulsion: (1)**
  - Colloid Thruster Life Testing and Modeling  
PI: Marese-Reading (JPL); ongoing
- **Segmented Telescope: (1)**
  - Demonstration of Advanced Wavefront Control for Segmented Aperture Telescopes  
PI: Tesch (JPL); ongoing
- **Starshade: (1)**
  - Starshade Petal Fabrication and Accuracy Demonstration at Full-Scale  
PI: Arya (Stanford); concluding
- **MIR Detectors: (2)**
  - Development of Ultra-Stable MIR Detector Array for Exoplanet Transit Spectroscopy  
PI: Staguhn (JHU); ongoing
- **EPRV: (1)**
  - A Novel Optical Etalon for Precision Radial Velocity Measurements  
PI: Vasisht (JPL); completed
- **Coronagraphy and Wavefront Sensing & Control: (17)**

# 23 Active or Completed Exoplanet SATs in 2025

## Coronagraphy (9)



- **Vortex Coronagraph High Contrast Demonstrations (2)**  
PI: Serabyn (JPL); completed 1, ongoing 1
- **Laboratory Demonstrations of High Contrast with Black Silicon Masks**  
PI: Riggs (JPL); ongoing
- **Technology Development in UV Coronagraphy**  
PI: Van Gorkum (Arizona); ongoing
- **Lab Demo of High Contrast Using PAPLC with High-Order Wavefront Sensor**  
Pueyo (STScI); ongoing
- **Laboratory Demonstration of Multi-Star Wavefront Control in Vacuum**  
PI: Belikov (NASAARC); ongoing
- **System-Level Demo of High-Contrast for Future Segmented Space Telescopes**  
PI: Soummer (STScI); completed
- **Super Lyot ExoEarth Coronagraph**  
PI: Trauger (JPL); completed
- **Lab Demonstration of High Contrast Using PIAACMC on a Segmented Aperture**  
PI: Belikov (NASAARC); completed

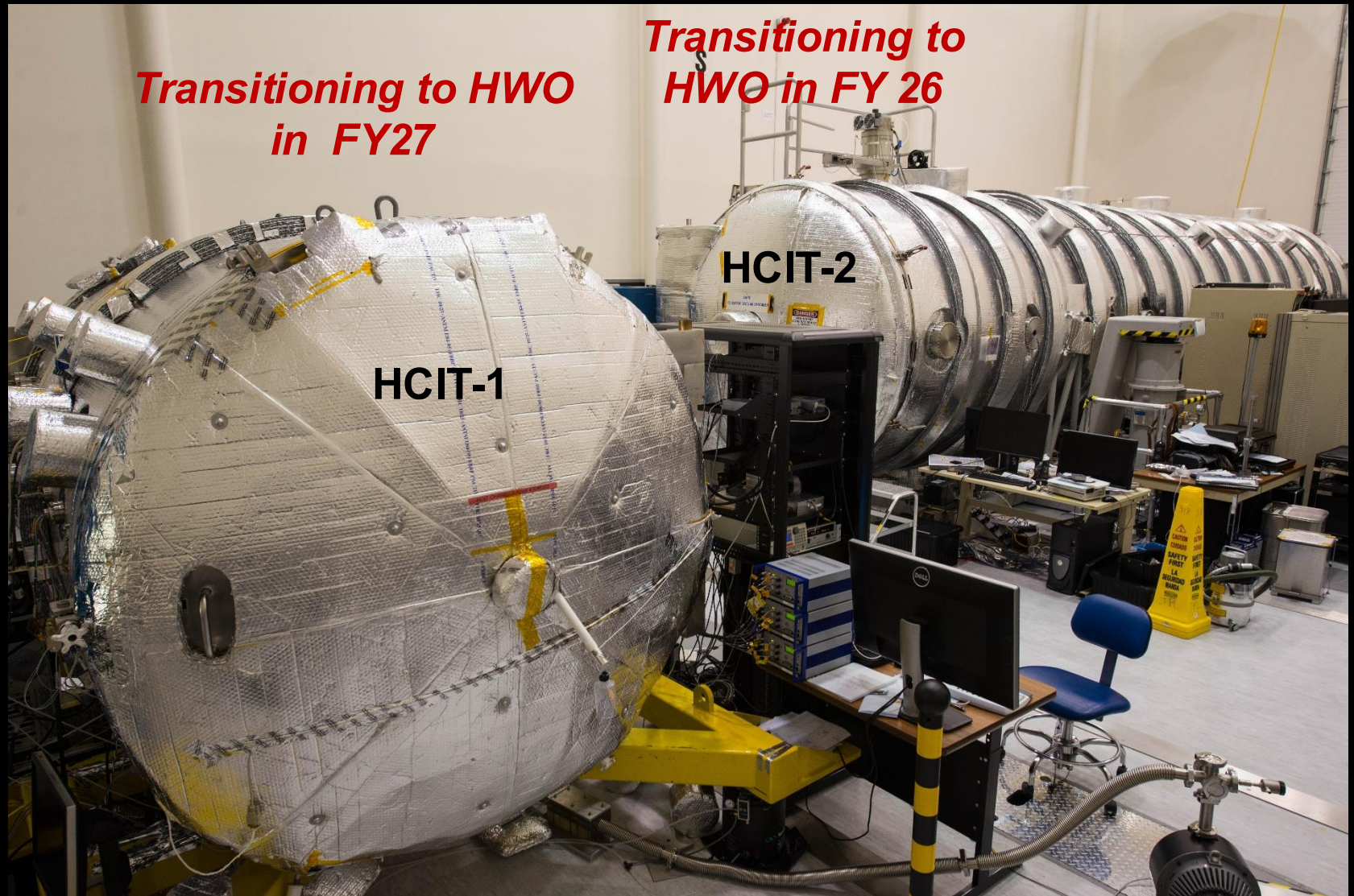
# 23 Active or Completed Exoplanet SATs in 2025

## Wavefront Sensing & Control: (8)



- **A Low-Order Hardware for Sensing and Control in Exoplanet Imaging**  
PI: Trauger (JPL); ongoing
- **Thermo-Optical Metrology for Exoplanet observatories**  
PI: Guzman (Arizona); ongoing
- **Robust Deep Contrast Imaging with Self-Calibrating Coronagraph Systems (2)**  
PI: Guyon (Arizona); completed 1, ongoing 1
- **Adaptive High-order Wavefront Control Algorithms for High-contrast Imaging**  
PI: Cahoy (MIT); ongoing
- **A Novel Asynchronous Integrating Latching controller for MEMS DMs**  
PI: Cook (U Mass); ongoing
- **Optimal Spectrograph and Wavefront Control Architectures Enabling Broadband**  
PI: Mawet (Caltech); completed
- **Dual-Purpose Coronagraph Masks for Enabling High-Contrast Imaging**  
PI: Wallace (JPL); ongoing

# High Contrast Imaging Testbed Facility at JPL



*Transitioning to HWO  
in FY27*

*Transitioning to  
HWO in FY 26*

# Emerging Technologies for Astrophysics Missions

- Nick Siegler (JPL) and Mario Perez (NASA HQ) facilitated a workshop at NASA Ames.
- Approximately 60 experts in **astrophotonics, advanced materials, quantum sensing, and AI/ML** participated in identifying technologies and astrophysics applications.
- The workshop participants stemmed from academia, industry, other government agencies, and NASA Centers.
- A Summary Report has been completed and is under NASA review; includes numerous technologies and suggestions for NASA Astrophysics.



# NASA Technosignatures Database

## Technosignatures

### Data Fields

Potential Extraterrestrial Activity (PEA)	Broad category the technosignature belongs to	Travel				Artifacts				Communications				Travel			
Technosignature Name	Canonical SETI name for the specific signal/phenomenon	Signatures of Non-Relativistic Solar-System Flyby Spacecraft				Signatures of Lurkers within the Solar System				Signatures of Solar System Body Surface Artifacts				Signatures of Stellar Gravitational Lens Relay Networks		Signatures of Spacecraft Exhaust	
<b>Technosignature Description</b>	Summary of the technosignature and why it is a technosignature	Low, meteors/satellites can mimic, adding more sensors and kinematic modeling improves discrimination				High — natural NEOs and human debris can mimic glints/polarization; specificity increases with repeating geometry-locked flashes + multi-band/radar confirmation, however, we can go visit these objects				Anomalous features indicative of nearby astronomical bodies				Relays stationed near the gravitational focal regions of the Sun (and of nearby stars) may be used for interstellar communication. Such relays exploit a star's gravitational lens to collimate and/or amplify transmissions, enabling efficient interstellar links. Conceptually, these relays could form a multi-node interstellar network.		Orbital rocket propulsion powered by antimatter-matter collisions, fusion, or fission.	
<b>Ambiguity Score</b>	Likelihood the signal cannot be mimicked by natural phenomena. Part of the Technosignature Scoring. (5=very unambiguous; 1=very ambiguous)	1	1	1	1	5	5	5	5	4	5	5	5	1	1		
<b>Ambiguity Description</b>	Short rationale for the specificity rating (main confounders and how mitigate)	Low, meteors/satellites can mimic, adding more sensors and kinematic modeling improves discrimination				High — natural NEOs and human debris can mimic glints/polarization; specificity increases with repeating geometry-locked flashes + multi-band/radar confirmation, however, we can go visit these objects				Medium/High, geologic look-alikes and human debris can mimic artificial signatures, but high ability to get additional data				High. The geometry (antipode of specific nearby stars) plus sub-arcsecond beams and characteristic drift rates makes astrophysical confusion unlikely. RTI remains the primary confounder.		Low — $\gamma$ -ray spectra can resemble natural sources; combining very large proper motion and linear transient alignments increases distinctiveness	
<b>Duration Score</b>	How long the technosignature is observable. Part of the Technosignature Scoring. Low should be on order of minutes or less, Medium is on order of a century or less, High is anything larger.	3	3	3	3	3	3	3	3	5	3	3	3	3	3		
<b>Duration Description</b>	Typical transience of the technosignature relative to scheduling and confirmation.	Medium, signals may be detectable from minutes to weeks				Medium, observables are brief and phase-dependent (mo-min) yet repeatable with orbital geometry; orbital residency of artifacts is expected to last for long periods of time				High — artifacts on bodies could persist for Myr-Gyr with minimal erosion, especially on airless bodies				Medium. Signals could be continuous (e.g., "new W" optical) or intermittent (beam-pointing schedules and Earth's position modulate observability on timescales from minutes to seasons).		Medium — engine burns are episodic/transient (seconds-hours) and may recur along trajectory; overall mission activity spans months-years	
<b>Extrapolation</b>	How close in scale the technosignature is to contemporary human technology. Part of the Technosignature Scoring	3	3	3	3	3	3	3	3	5	3	3	3	1	1		
<b>Extrapolation Description</b>	Brief comparison to Earth technology analogs: infrastructure, or energetics.	Medium, we could potentially make these craft, don't currently have the capability to produce "worldship"-style craft				Medium, plausible size (~1-100 m) comparable to current human satellites/probes, although we do not have the technology to send these linkers to other planetary systems ourselves				High — expected artifact scales and materials overlap with contemporary human spacecraft/infrastructure				Medium. Individual node hardware (meter class optics/radios) is comparable to current human tech; the required placement (ICSS AU) and longevity elevate overall scale.		Low — required powers (TW-10 <sup>17</sup> TW) and exhaust signatures far exceed current Earth technology.	
<b>Inevitability Score</b>	How likely the technosignature is produced if the enabling technology exists. Part of the Technosignature Scoring	3	3	3	3	1	1	1	1	1	1	1	1	5	5		
<b>Inevitability Description</b>	Rationale tying the technosignature to common byproducts vs niche deployments.	Medium, if ETI explores, it may be cheap to send out many slow probes.				Low, co-orbiters/probes are natural stability vantage points if surveillance/relay is desired, but there is no requirement that ETI would value this usage				Low — if many exploratory probes from passing civilizations are common, some could accumulate on stable surfaces or niches, however, there is a possibility that exploratory probes have not exited the solar system				Low, we may not be a good system to host such an object, ETI may not be able/willing to travel such distances.		High — if rocket-based interstellar travel is used, exhaust (by X/R) is physically unavoidable	
<b>Information Score</b>	How much we learn about ETI from a detection. Part of the Technosignature	5	5	5	5	5	5	5	5	5	5	5	5	3	3		

### Search Approaches

Description



Wavelength



Current/Future



Facilities



Tech Needs?



Ambiguity



Citations



- Will inform new investigators in the field, educators, public, philanthropists
- Which current observatories can search for which technosignatures?
- Which technosignatures have never been investigated?
- Intended to be made public on a NASA website

# Thank You!

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**Deputy Program Chief Technologist**



**Brendan Crill  
(JPL)**

**Deputy Technology Manager**



**Pin Chen  
(JPL)**

# Welcome Back!

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## Deputy Program Chief Technologist



**Rhonda Morgan**  
**(JPL)**