Habitable Worlds Observatory

Technology Development Plan

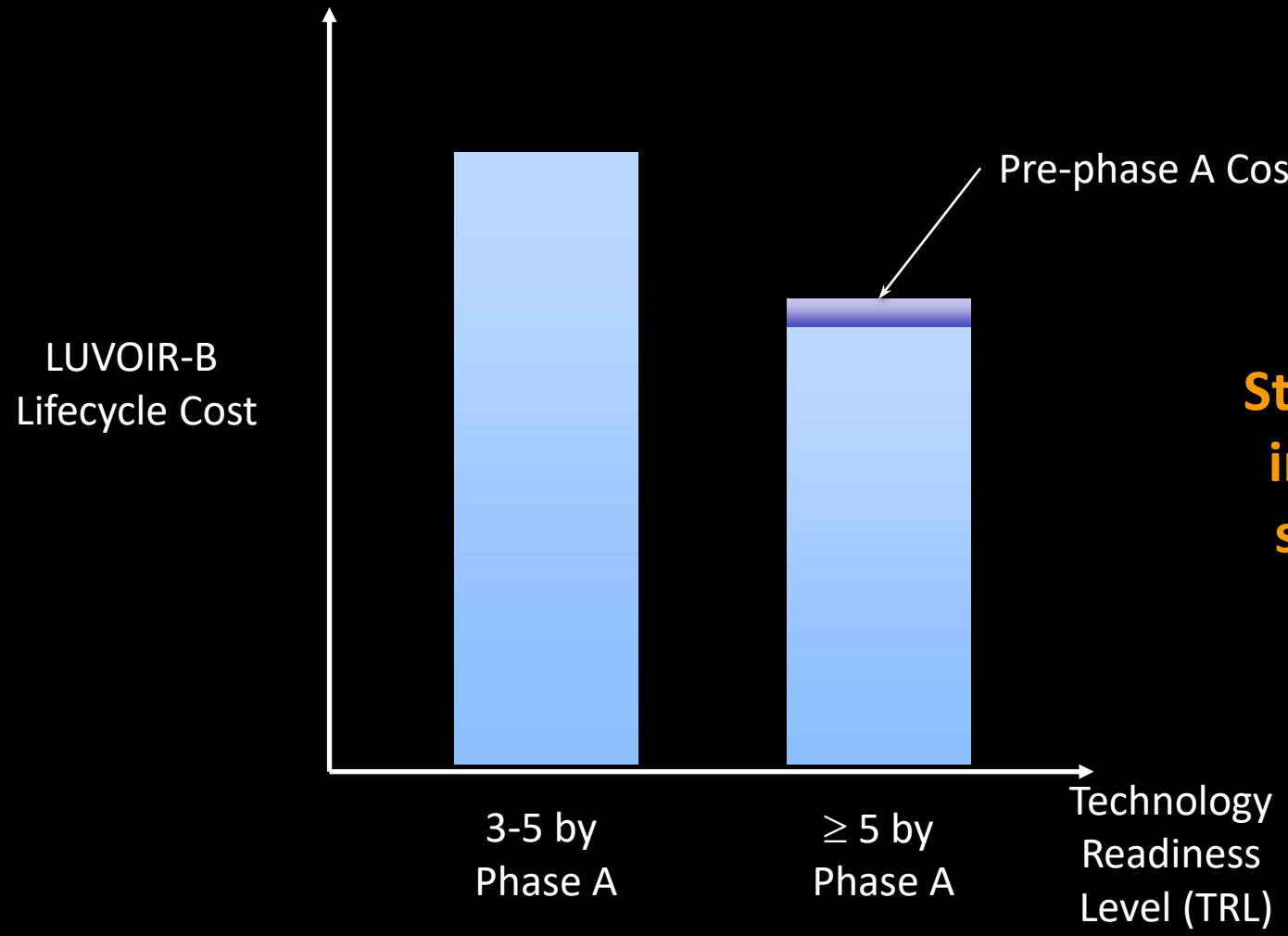
2025 July 29

HWO25 – Towards the Habitable Worlds Observatory:
Visionary Science and Transformative Technology

Matthew R. Bolcar (GSFC), Feng Zhao (JPL), Paul Scowen (GSFC), and many others…
HWO Technologists

HABITABLE WORLDS OBSERVATORY

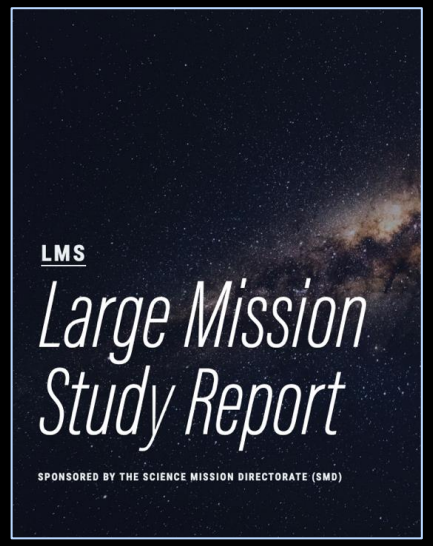
Early Technology Development Saves Money



Strategic investment in Pre-phase A can save cost over the project lifecycle

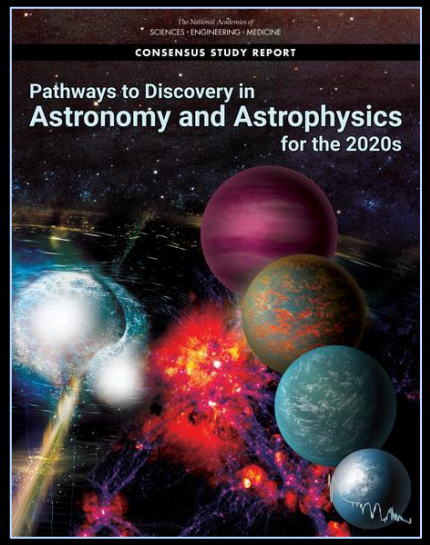
The LUVOIR Mission Concept Study Final Report, 2019

A New Approach to Developing Flagship Missions



"Recommendation: Move the current NASA TRL standard to the left for large missions…achieve TRL 6 by Mission Definition Review…"

"Mature the architecture and technology fully before starting the development phase…"



"Prior to commencing mission formulation, a successful Great Observatories Mission and Technology Maturation program must be completed…"

Roman Space Telescope demonstrates: When architected for success, flagship missions can deliver on cost and schedule

Robust, Strategically Executed Technology Development...

…demonstrates technical feasibility,

…reduces overall programmatic risk,

…and enables transformative scientific discovery with HWO.

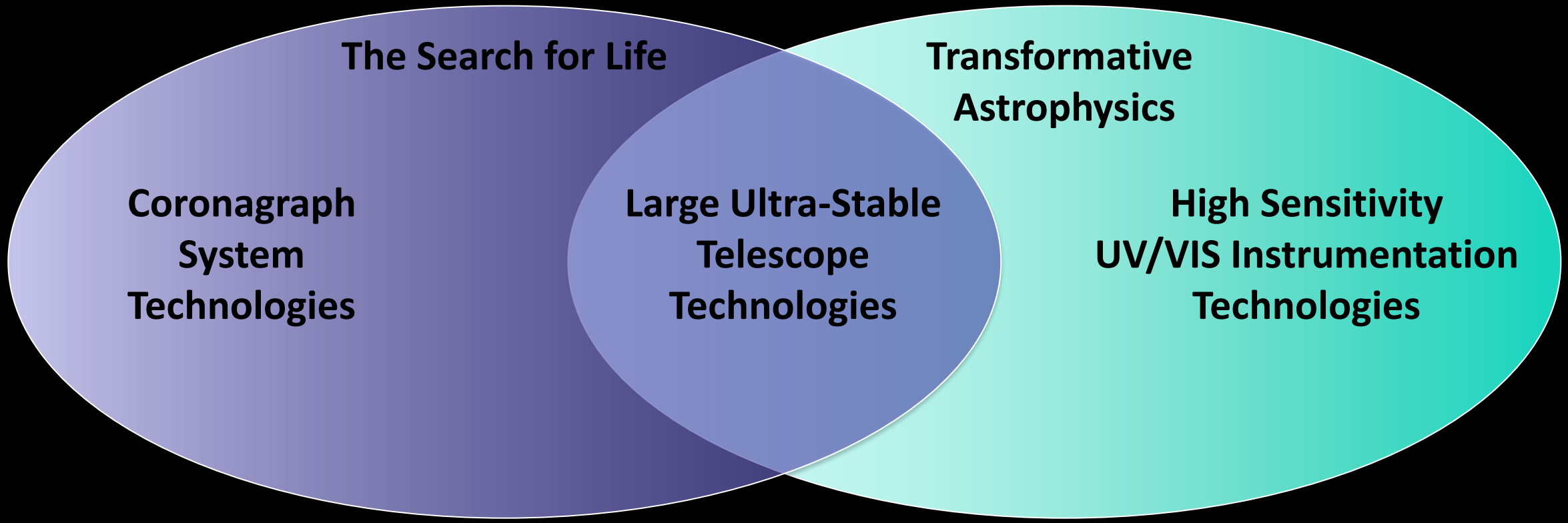
We've Defined A Robust, Strategic Technology Development Plan For HWO

- ✓ Identified technology and engineering gaps in formulating and implementing HWO
- ✓ Defined roadmaps, milestones, and success criteria to close those gaps
- ✓ Scoped the cost, schedule, and human resources needed to implement the plan
- Poised to execute *and evolve* the plan

We've Defined A Robust, Strategic Technology Development Plan For HWO

- ✓ Identified technology and engineering gaps in formulating and implementing HWO
- ✓ Defined roadmaps, milestones, and success criteria to close those gaps
- ✓ Scoped the cost, schedule, and human resources needed to implement the plan
- Poised to execute *and evolve* the plan

Technology Needs Are Informed By Science And Architecture



Three Technology Tracks aligned to the system architecture.

Technology Lanes Further Identify Individual Gaps

Coronagraph System Technologies

- Starlight Suppression
- Deformable Mirrors
- Contrast Stabilization
- Low-noise Detectors
- Spectroscopy
- Near-UV Capability
- Post-Processing

Large Ultra-Stable Telescope Technologies

- Ultra-stable Mirrors
- Ultra-stable Structures
- Thermal Control System
- Sensing & Control
- Low-Disturbance Systems
- Deployable Systems

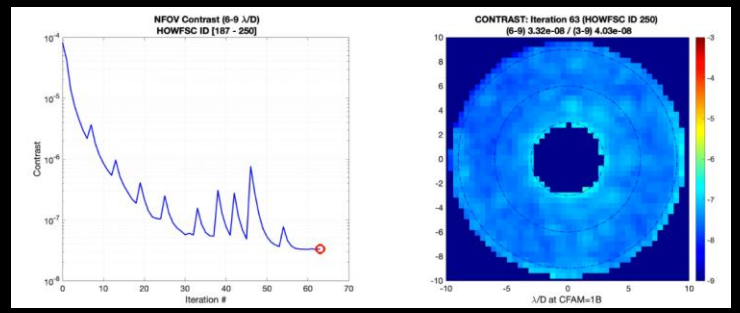
High Sensitivity UV/VIS Instrumentation Technologies

- Far-UV Mirror Coatings
- Near-UV / VIS Detectors
- Far-UV Detectors
- Multi-object / Integral Field Spectroscopy
- UV Gratings & Filters

Recent progress has advanced the state-of-the-art across all tracks.

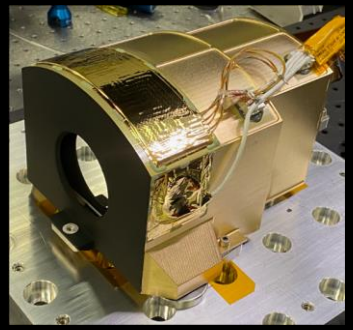
Roman CGI Establishes The State-of-the-Art For High-Contrast Imaging

NASA/C. Gunn



4.0×10^{-8}
Raw Contrast
3-9 λ/D

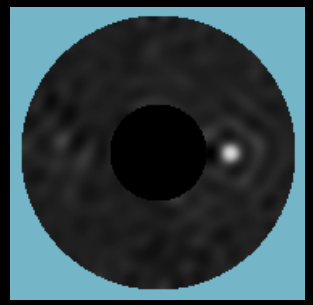
48 x 48
Deformable
Mirror



Proximity
Electronics

Camera
Body

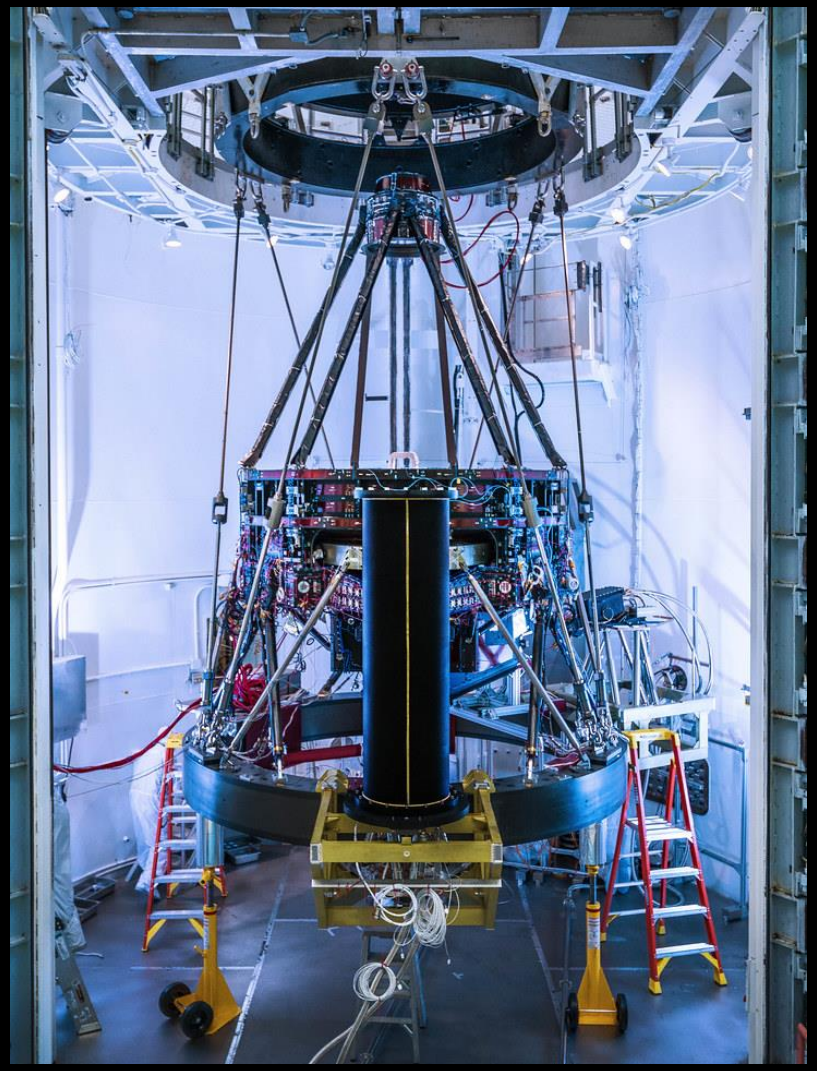
Ref Star Target Star Target Star - Roll



After Post Processing:
Contrast Floor = 3.94×10^{-9}

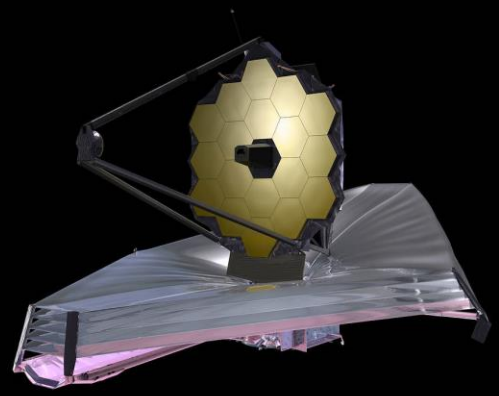
CGI/JPL

Webb and Roman Demonstrate Exceptional Stability

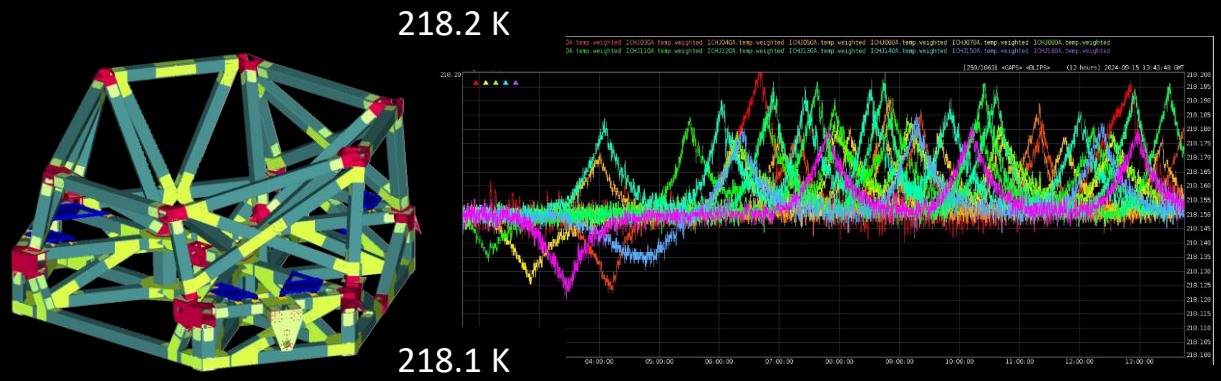


NASA/C. Gunn

Roman Telescope demonstrates 10s of picometer wavefront error stability.

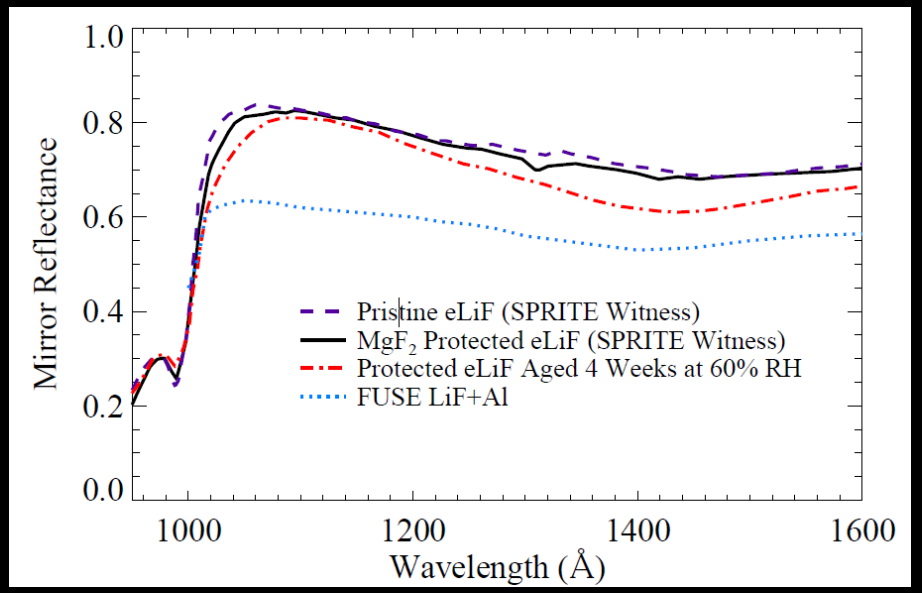


JWST exhibits extraordinary on-orbit stability.

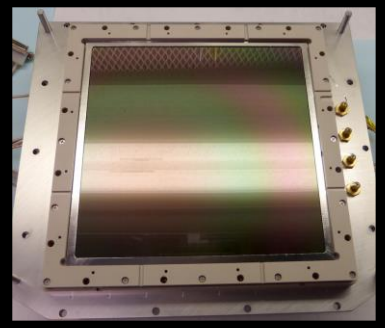


Roman Instrument Carrier achieves 10 mk stability

CubeSats and Sounding Rockets Lead The Way For UV Instrumentation



SPRITE CubeSat Mirror Coating



20x20 cm Micro-channel Plate for DEUCE Sounding Rocket

FORTIS & JWST microshutters (left) with next gen devices (right)

See: Tuttle, et al. 2024 for comprehensive review of state-of-the-art.

We've Defined A Robust, Strategic Technology Development Plan For HWO

- ✓ Identified technology and engineering gaps in formulating and implementing HWO
- ✓ Defined roadmaps, milestones, and success criteria to close those gaps
- ✓ Scoped the cost, schedule, and human resources needed to implement the plan
- Poised to execute *and evolve* the plan

HABITABLE WORLDS OBSERVATORY

TECHNOLOGY ROADMAP

2025

- Coronagraph Testbeds Available For Use
- Keck Sensing & Control Demo
- Ultra-stable & System Testbeds Available For Use
- MCR — Critical Technology Demonstration Milestone

Ultra-stable Telescope System

- System Architecture
- Meter-Class Mirror Cell
- Industry Initial Efforts
- Segment Sensing & Control
- Ultra-stable Structures
- Disturbance Isolation
- Deployable Baffle

Leverage expertise and leadership of our industry partners.

Coronagraph System

- Coronagraph System
- Large Deformable Mirrors
- Coronagraph Wavefront Sensing
- Coronagraph Visible and Near IR Detectors
- Near-UV Coronagraph Science & Technology Investigation

Use new and existing testbeds at multiple institutions

High-Sensitivity UV & Instrument Technologies

- Mirror Coating Uniformity Demo
- Far-UV Multi-object Selection Device
- Large-format Far-UV Detector
- Near-UV/Visible Detectors

Develop through strategic directed and competed investments.

Emerging Technologies

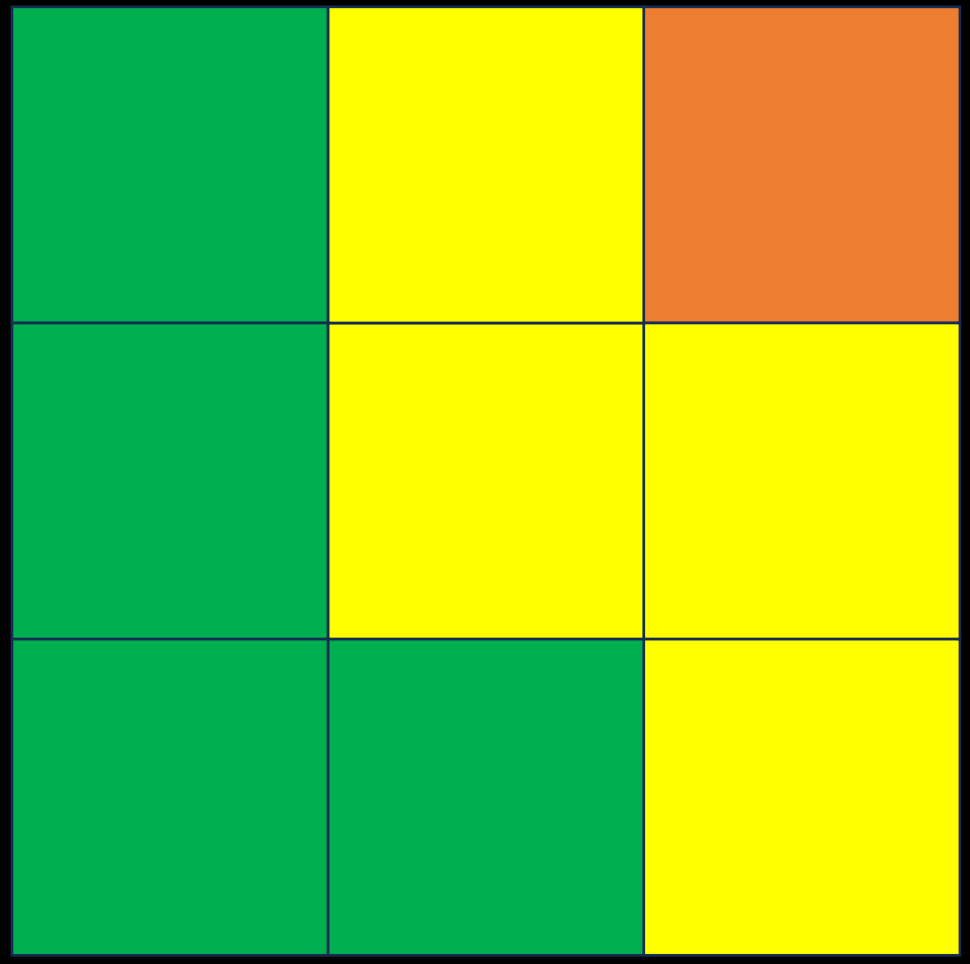
- Artificial Intelligence
- Quantum Imaging and Quantum Sensors
- Photonic and Metamaterials

Currently Funded	Development / Fabrication
Design and Analysis	Characterization / Demonstration

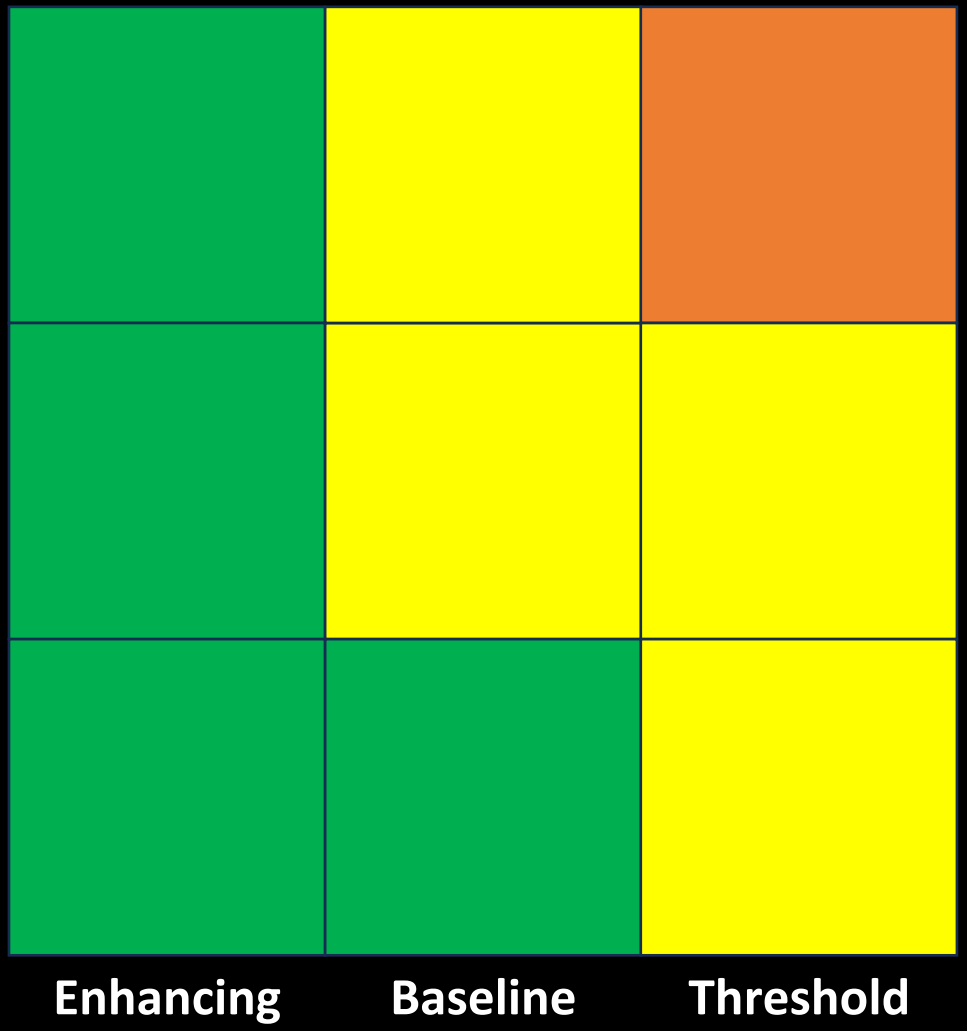
We've Defined A Robust, Strategic Technology Development Plan For HWO

- ✓ Identified technology and engineering gaps in formulating and implementing HWO
- ✓ Defined roadmaps, milestones, and success criteria to close those gaps
- ✓ Scoped the cost, schedule, and human resources needed to implement the plan
- Poised to execute *and evolve* the plan

Prioritizing Gaps Helps Focus Limited Resources

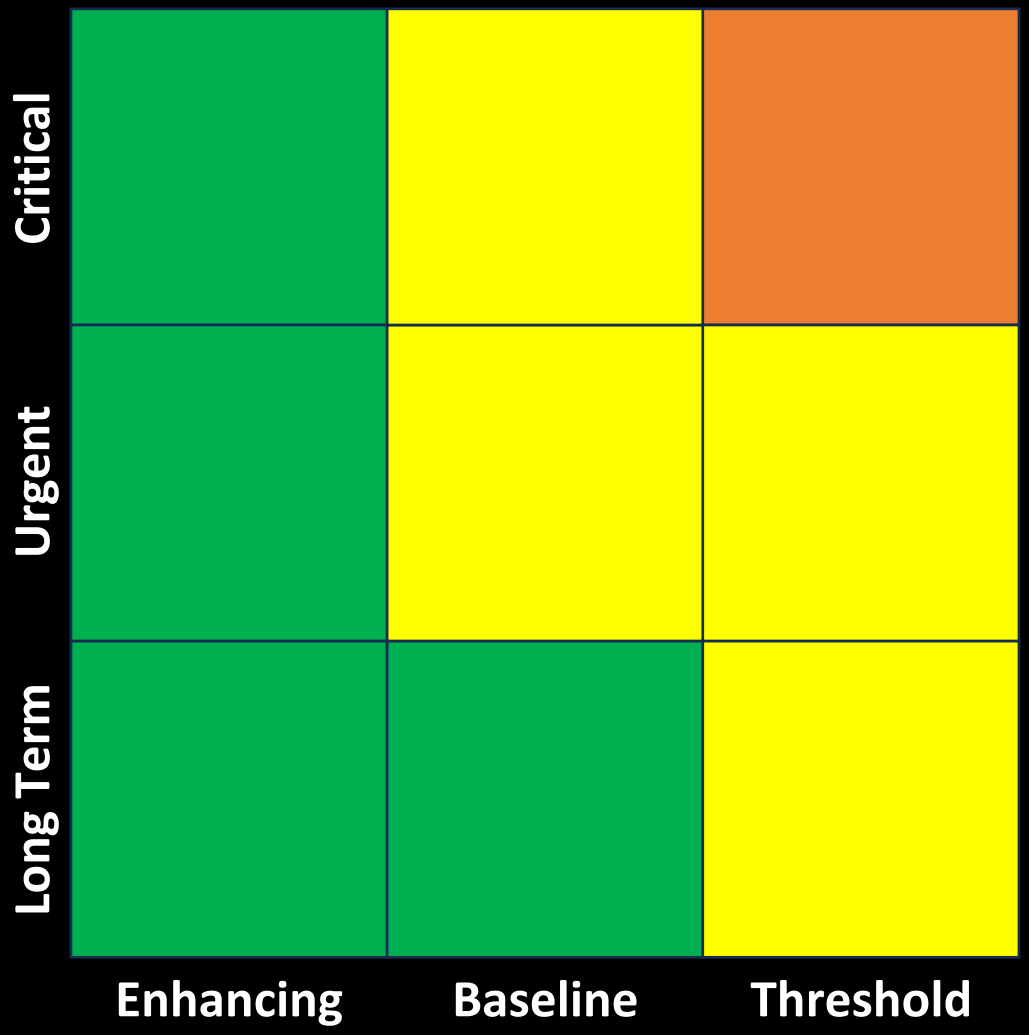


Prioritizing Gaps Helps Focus Limited Resources



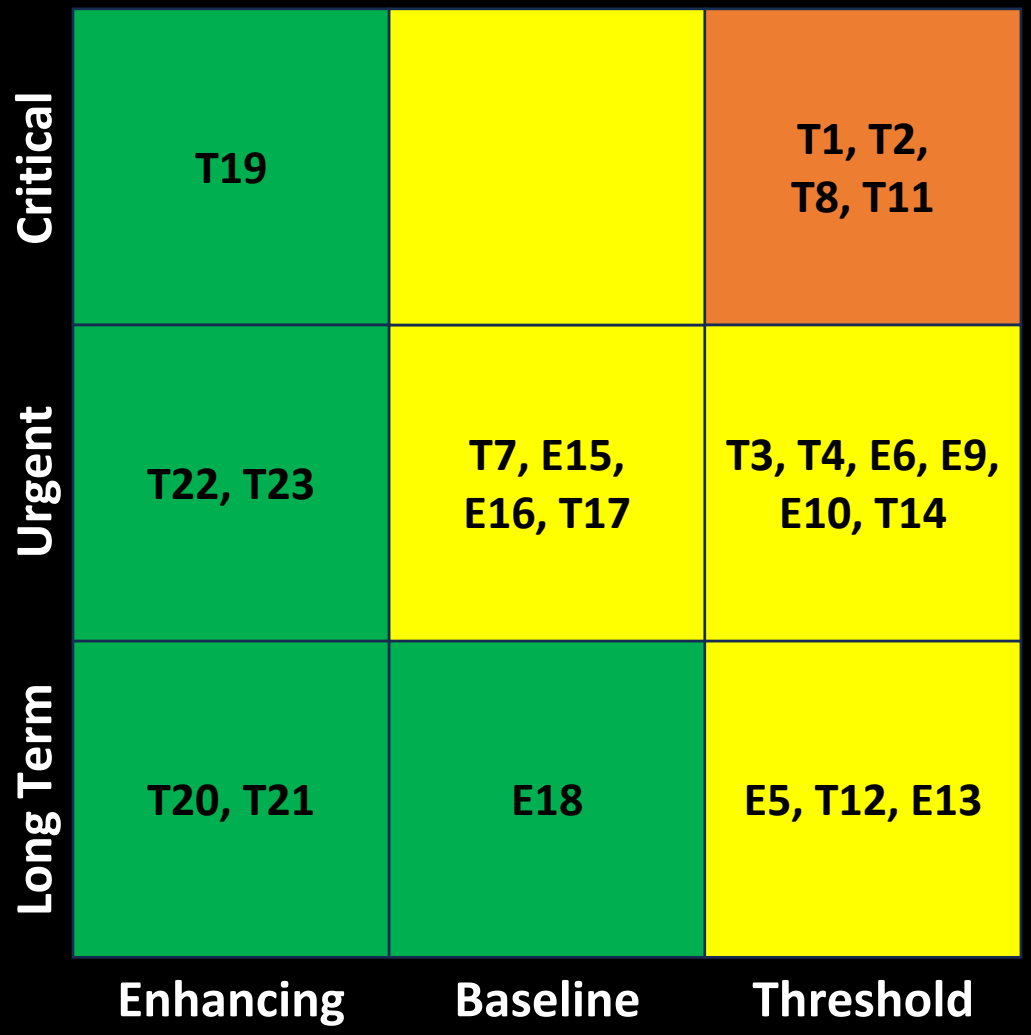
Ranks how enabling the technology is to HWO Mission

Prioritizing Gaps Helps Focus Limited Resources

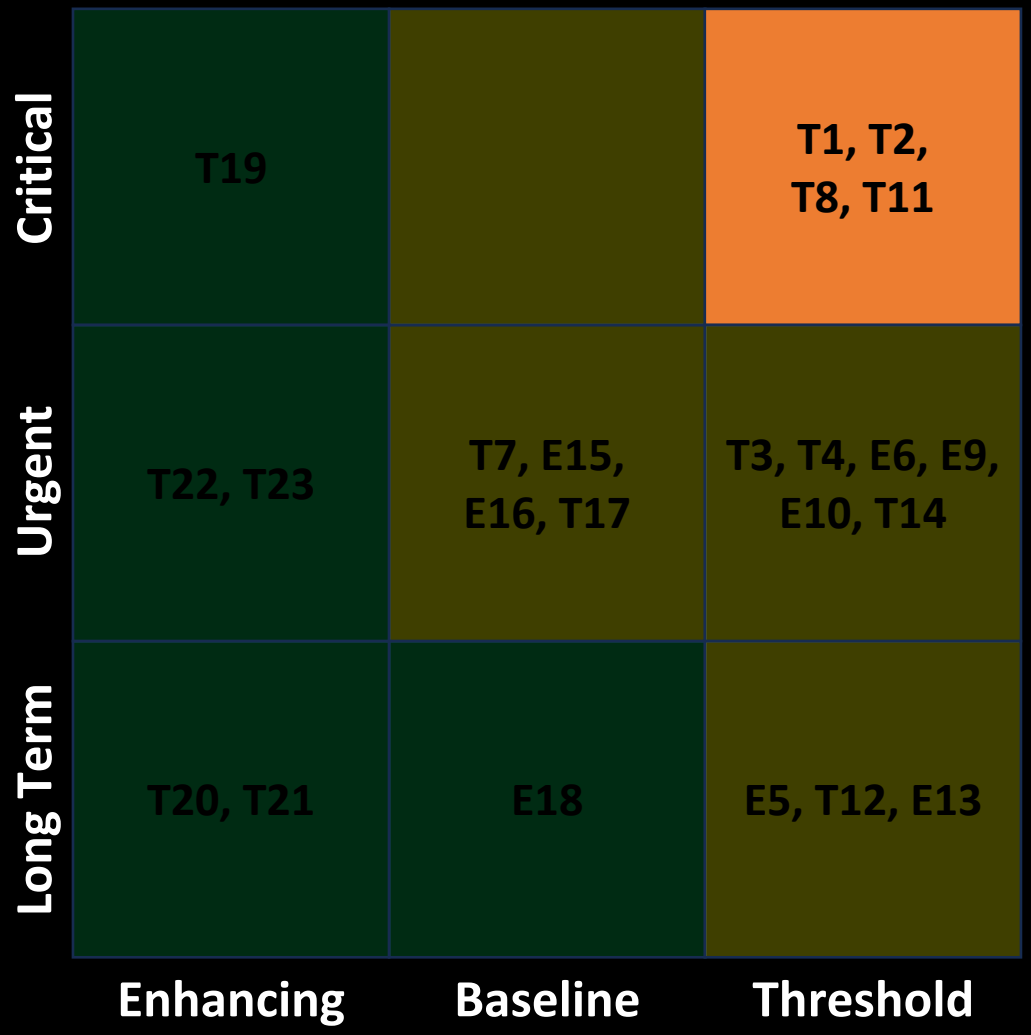


Ranks how urgently the technology needs to be demonstrated to inform the HWO design.

Prioritizing Gaps Helps Focus Limited Resources

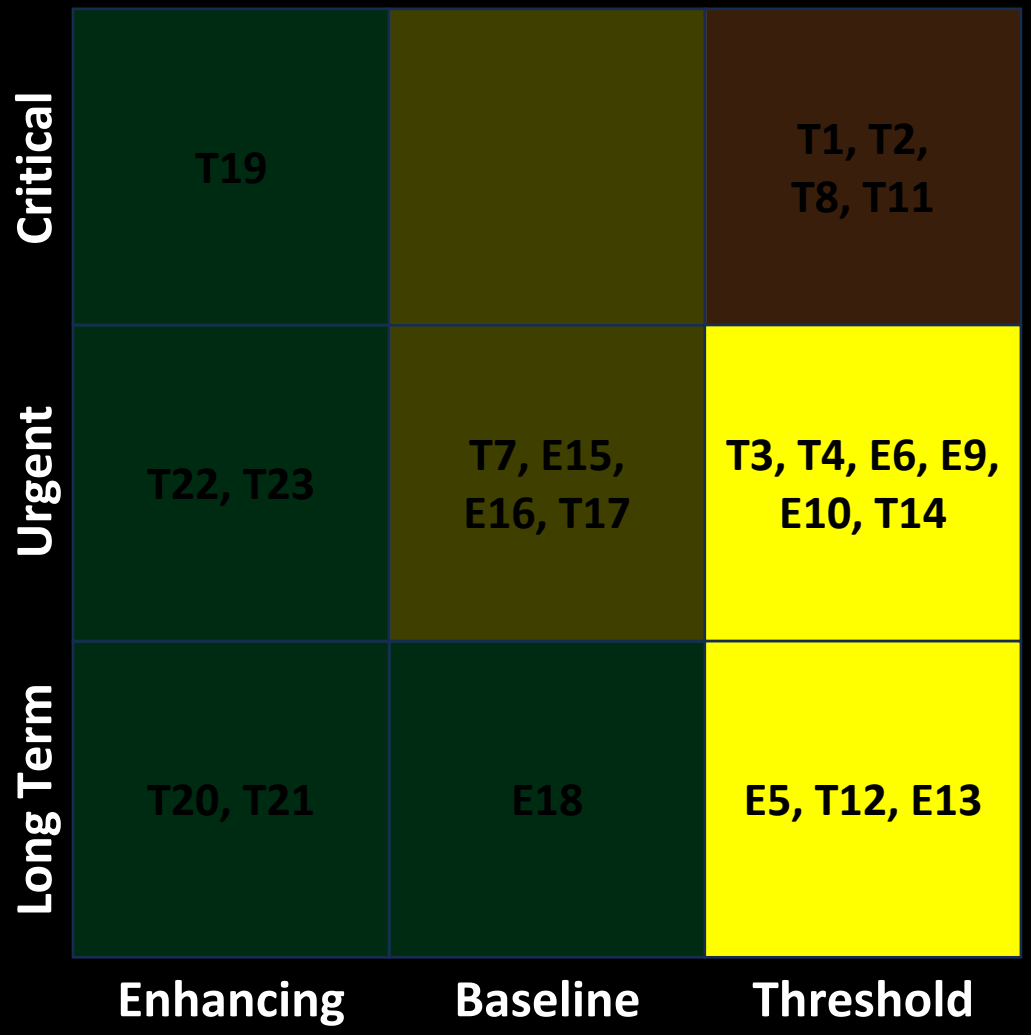


Prioritizing Gaps Helps Focus Limited Resources



Contrast, Contrast Stability, Ultra-stable Mirrors, Sensing & Control

Prioritizing Gaps Helps Focus Limited Resources

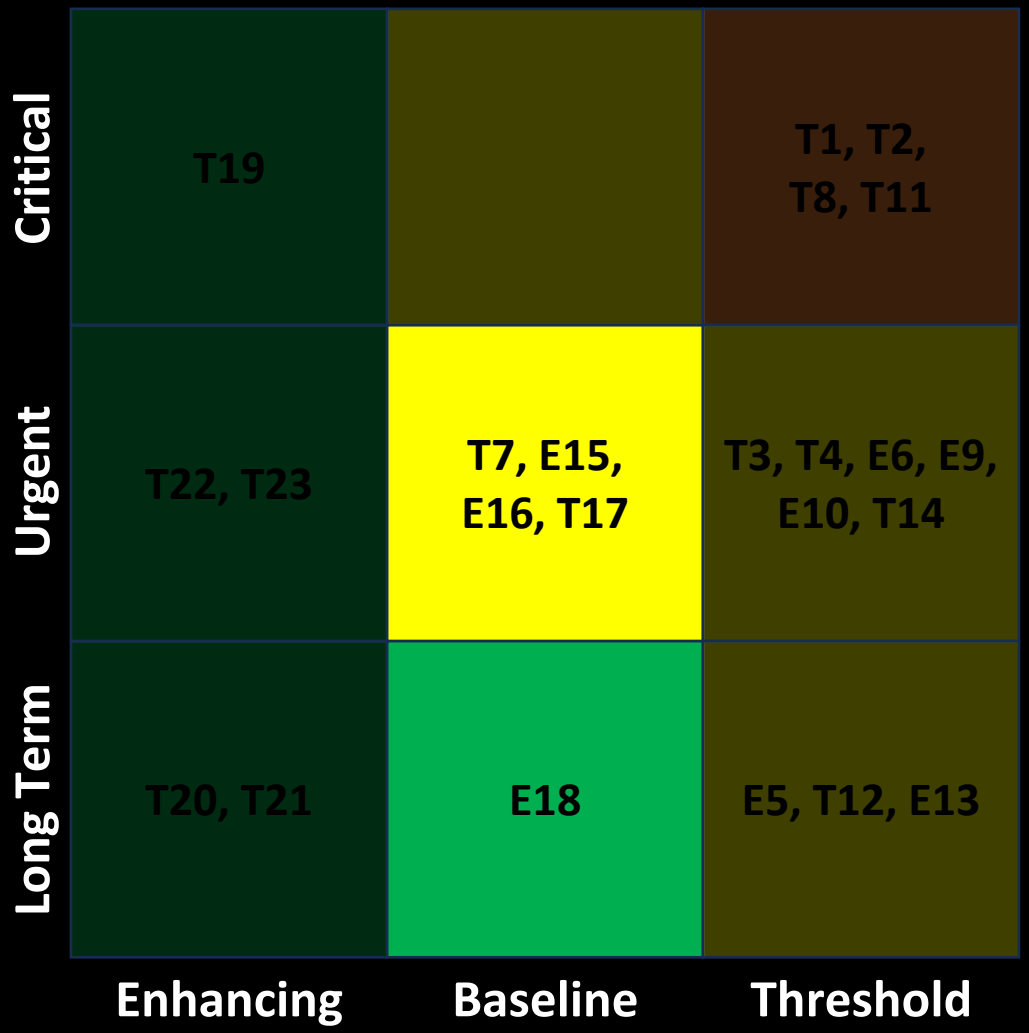


Other Coronagraph & Ultra-stable Telescope Technologies

Plus

Far-UV Coatings

Prioritizing Gaps Helps Focus Limited Resources



UV/VIS Detectors, Gratings, Filters, and Spectroscopy

Plus

NUV High-Contrast Capability

Prioritizing Gaps Helps Focus Limited Resources

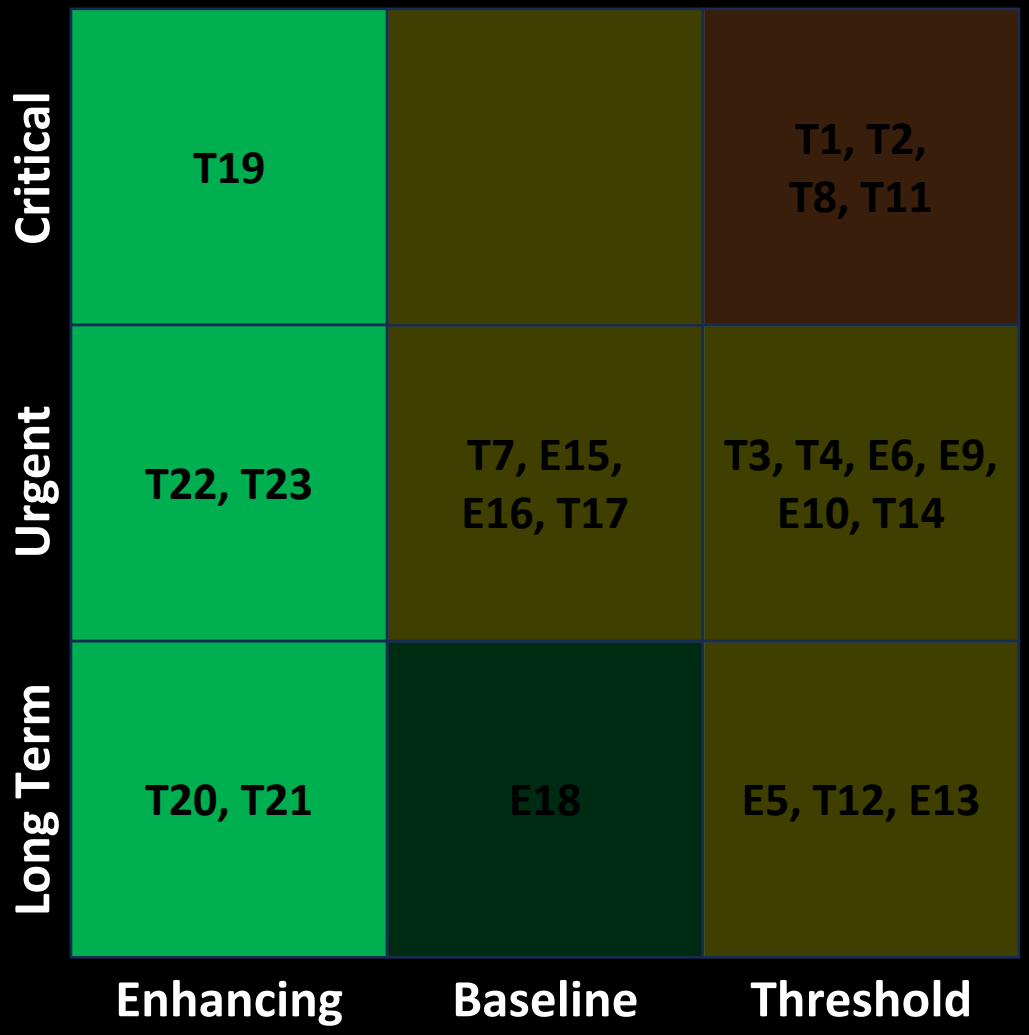
Superconducting Detectors

Photonics

Artificial Intelligence

Quantum Sensors

Meta Surfaces



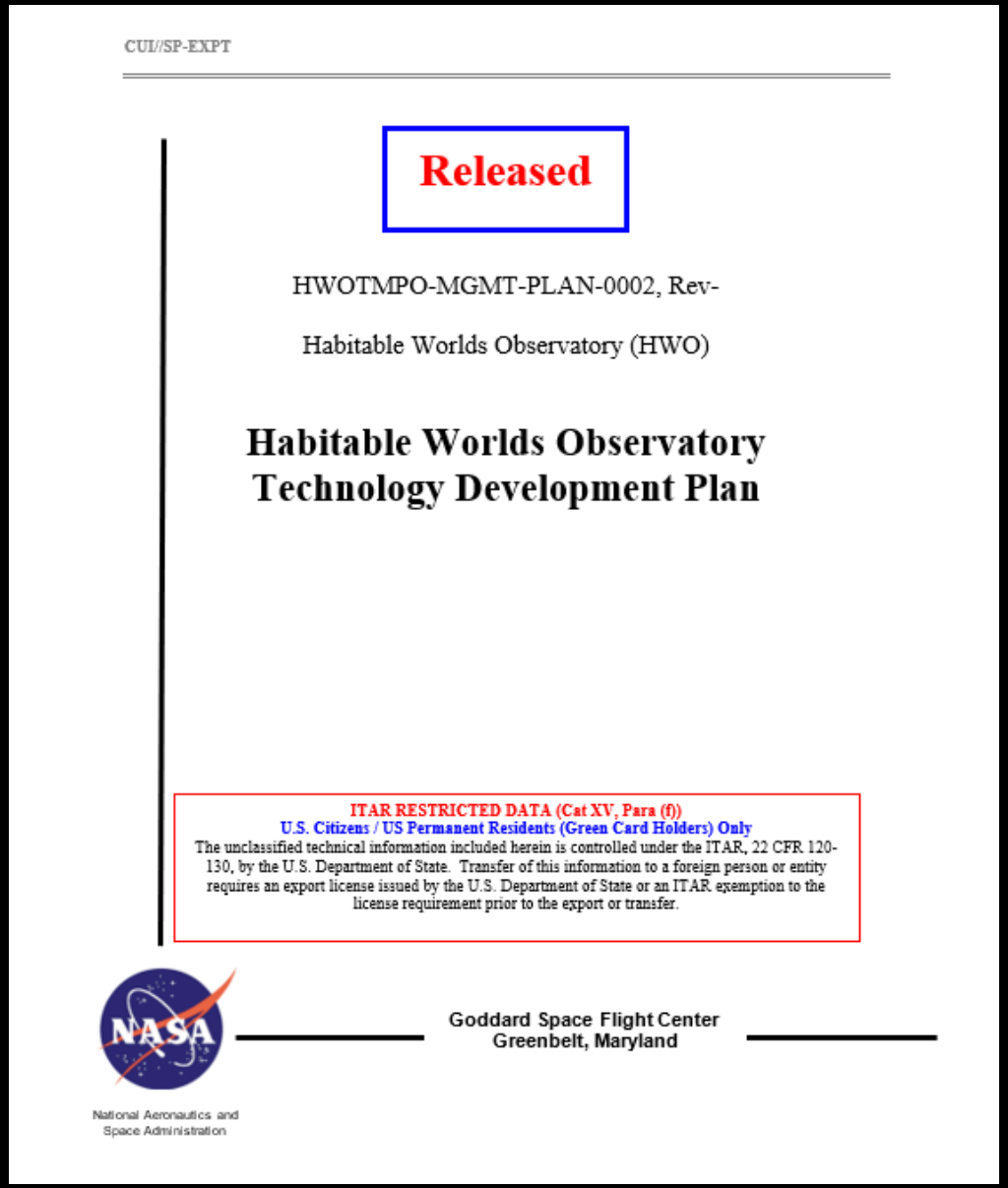
We've Defined A Robust, Strategic Technology Development Plan For HWO

- ✓ Identified technology and engineering gaps in formulating and implementing HWO
- ✓ Defined roadmaps, milestones, and success criteria to close those gaps
- ✓ Scoped the cost, schedule, and human resources needed to implement the plan
- Poised to execute *and evolve* the plan

Our Technology Development Plan Has Been Delivered to NASA HQ

110 pages of Technology Goodness

A public version is being prepared as an article for the SPIE Journal of Astronomical Telescopes, Instruments, and Systems (JATIS) later this fall



CUI//SP-EXPT

Released

HWOTMPO-MGMT-PLAN-0002, Rev-

Habitable Worlds Observatory (HWO)

Habitable Worlds Observatory Technology Development Plan

ITAR RESTRICTED DATA (Cat XV, Para (f))
U.S. Citizens / US Permanent Residents (Green Card Holders) Only
The unclassified technical information included herein is controlled under the ITAR, 22 CFR 120-130, by the U.S. Department of State. Transfer of this information to a foreign person or entity requires an export license issued by the U.S. Department of State or an ITAR exemption to the license requirement prior to the export or transfer.

National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

Our Technology Plan is in place.

We have a risk-based process to evolve that plan in response to challenges.

Our critical technologies continue to advance to enable HWO's transformative scientific discovery.