National Aeronautics and Space Administration

HABITABLE WORLDS OBSERVATORY

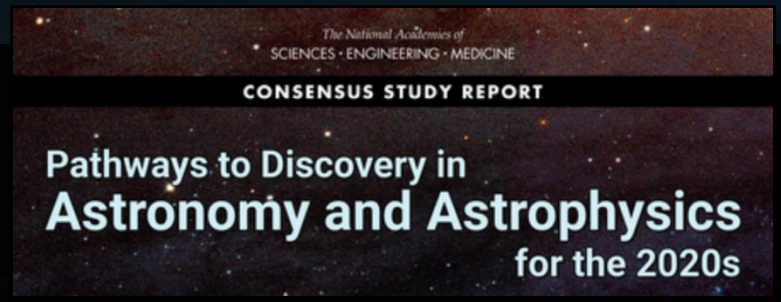
Habitable Worlds Observatory (HWO) Technology Maturation Project Office

Lee Feinberg, HWO Principal Architect
NASA Goddard Space Flight Center

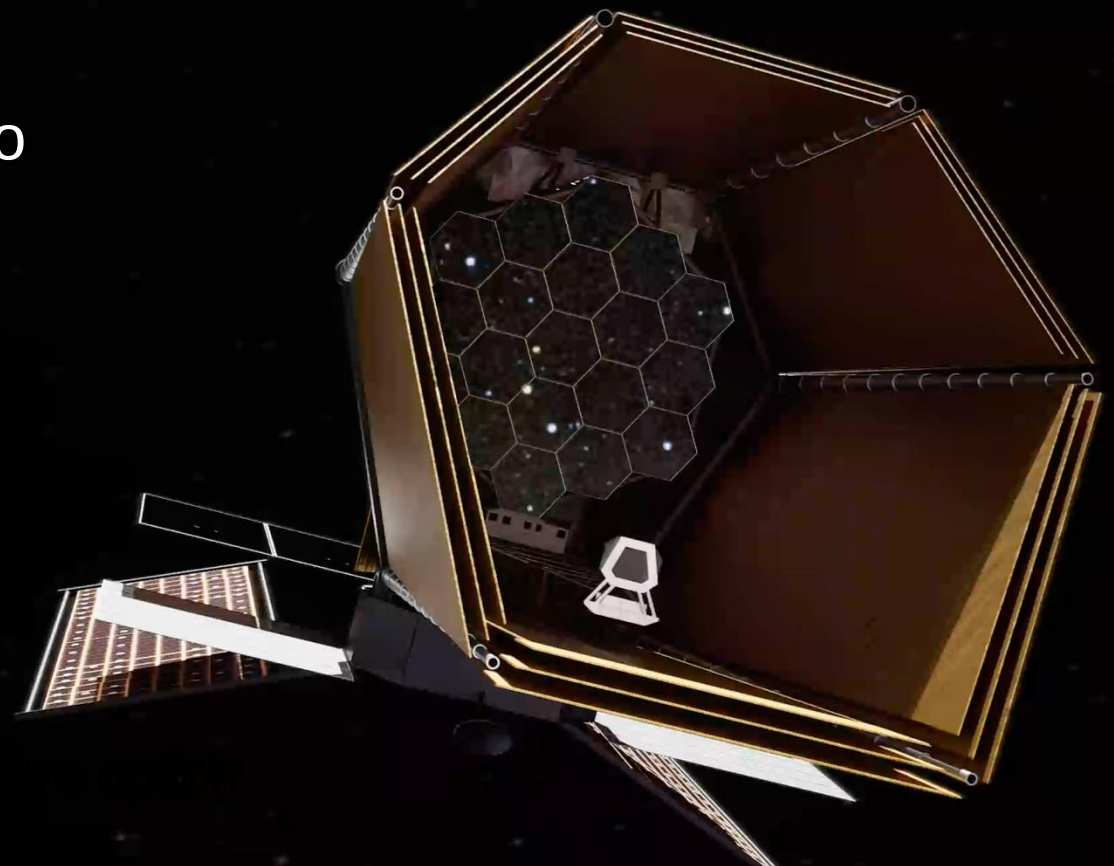
John Ziemer, HWO Pre-Formulation Architect
Jet Propulsion Laboratory

What is the Habitable Worlds Observatory?

NASA's next flagship mission concept recommended by Astro2020 Decadal Survey



A super-Hubble to search for life in the universe and perform transformative astrophysics



Key Improvements needed:

~10x in telescope stability vs. RST

~100x in contrast vs RST/CGI

Large aperture (>=6m)

New Project Office Started August 1st

- Builds off of prior activities of the Science Technology Architecture Team (START) and Technical Assessment Group (TAG) committees
- Priority this first year has been organizing, planning, and leading science, technology and architecture efforts in an integrated way
  - Technology roadmap is a key deliverable
- Community Science and Instrument Team call out now
- Quarterly meetings with JAXA, CSA and ESA have begun coordinated by NASA HQ
- Community led HWO Science and Technology Conference, Bloomberg Center, Washington DC July 28-31st, opportunity to share and hear about science cases and technology for HWO

HWO Project Office

* JPL ex-officio
° Interim

Project Leadership

L. Feinberg, Principal Architect

S. Smith, Project Manager°

J. Ziemer, Pre-Formulation Architect*

Science

G. Arney, Project Scientist°

A. Roberge, Pre-formulation Scientist°

B. Mennesson, Pre-formulation Scientist*

Deputy PS: Mike McElwain
Deputy PFS: Erin Smith
Deputy PFS: Pin Chen*
Coronagraph Instr Sci: Vanessa Bailey*
High-Contrast Spectr. Sci: Neil Zimmerman
Camera Instr. Scientist: Tom Greene, Ames
UV Instrument Scientist: Paul Scowen
Exoplanet Theme Ld: Chris Stark
Exoplanet Theme Ld: Renyu Hu*
Astrophysics Theme Ld: Jason Rhodes*
Astrophysics Theme Ld: Allison Youngblood
Solar Systems Ld: Lynnae Quick

Testbeds

B. Sitarski, Deputy Principal Architect

C. Baker* JPL Testbed Lead*

NASA HOST Lead: M. McElwain
HOST Systems: T. Groff
Keck Demo: M. Troy*

Systems

M. Menzel, Mission System Engineer

A. Liu, Deputy MSE

M. Levine*, Systems Modeling

Servicing & Instrument Systems: J. Van Campen
High Contrast Sys: C. Noecker
Payload Systems: J. Abel
High Contrast Error Budgets: Brian Kern
Systems Design and Modeling teams

Technology

M. Bolcar, Chief Technologist

F. Zhao, Deputy Chief Technologist*

Coronagraph Technology: Ilya Poberezhskiy/TBD
Telescope Technology: TBD
UV/Instrument Technology: Paul Scowen
SME: D. Redding*
SME: P. Stahl, MSFC
SME: R. Belikov, Ames

Larger Science and Engineering Project Development Team supporting various studies

Following HQ's Guidance for HWO

Hubble Servicing Mission 4

Planned in-space servicing

Robotic servicing at Sun-Earth L2

Evolve technology

- Build upon current NASA investments and TRL-9 technology
- JWST segmented optical telescope system
- Roman coronagraph

Next generation rockets

- Larger telescope aperture sizes
- Leverage opportunities offered by large fairings to facilitate mass & volume trades

Build to schedule

- Mission Level 1 Requirement (e.g., Planetary mission strategy)

Robust margins

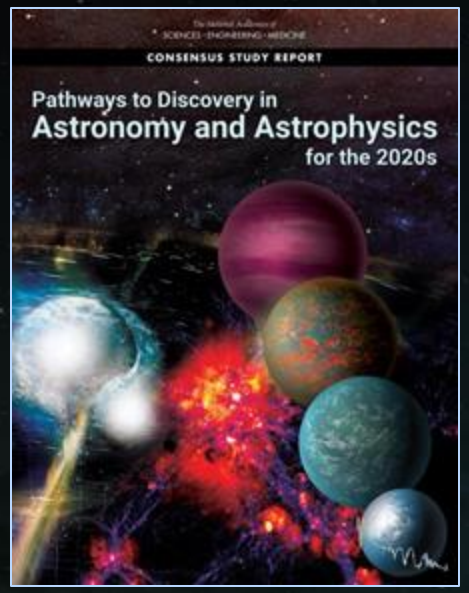
Design with large scientific, technical, & programmatic margins

Mature technologies first

- Reduce risk by fully maturing technologies prior to the development phase

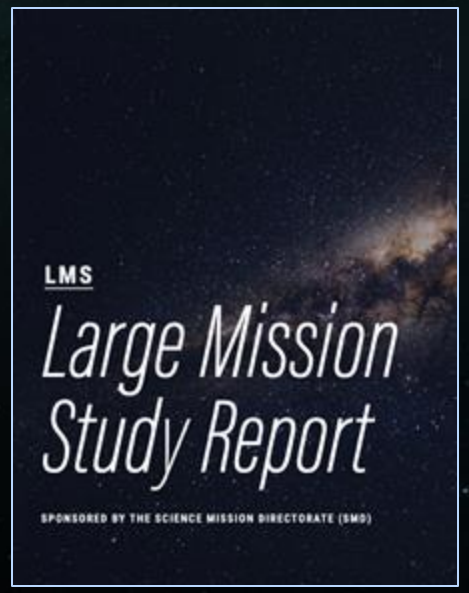
Dr. Mark Clampin, NASA Astrophysics Director, APAC presentation (slide 33) – March 29, 2023

The 2020 Decadal Survey and SMD Large Mission Study Set The Vision for Habitable Worlds Observatory Technology Maturation Project



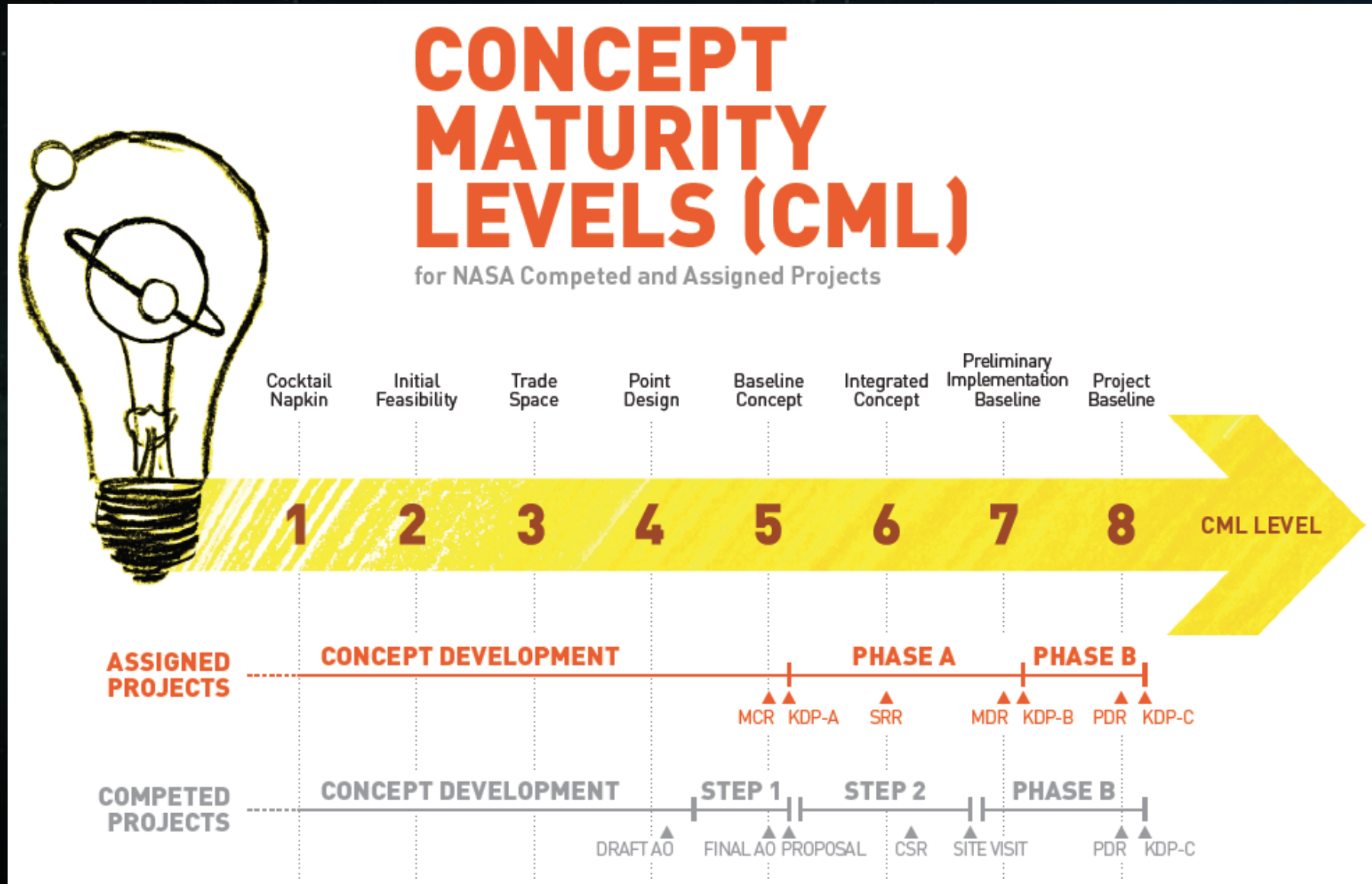
"Prior to commencing mission formulation, a successful Great Observatories Mission and Technology Maturation program must be completed, and a review held to assess plans in light of mission budgetary needs and fiscal realities."

"Design problems are baked into the cake at the start, and not uncovered until you have eaten half the cake."



- The Habitable Worlds Observatory Technology Maturation Project (HWO TMPO) has been created to meet the 2020 Decadal Survey and SMD Large Mission Study (LMS) recommendations
- From 2024 to 2030, HWO TMPO will:
  - Use "Concept Maturity Levels" (CMLs), endorsed by the LMS, to keep pace and set intermediate milestones for concept and technology maturity during pre-formulation
  - Engage the science and technology community to fully explore the trade space, within programmatic boundaries, before determining the baseline observatory
  - Strategically invest in critical technologies to meet the Decadal Survey's ambitious science goals prior to an independent review and start of Phase A by 2030

Concept Maturity Levels



Reviewed and determined not to contain CUI.

The Six Dimensions of Concept Maturity

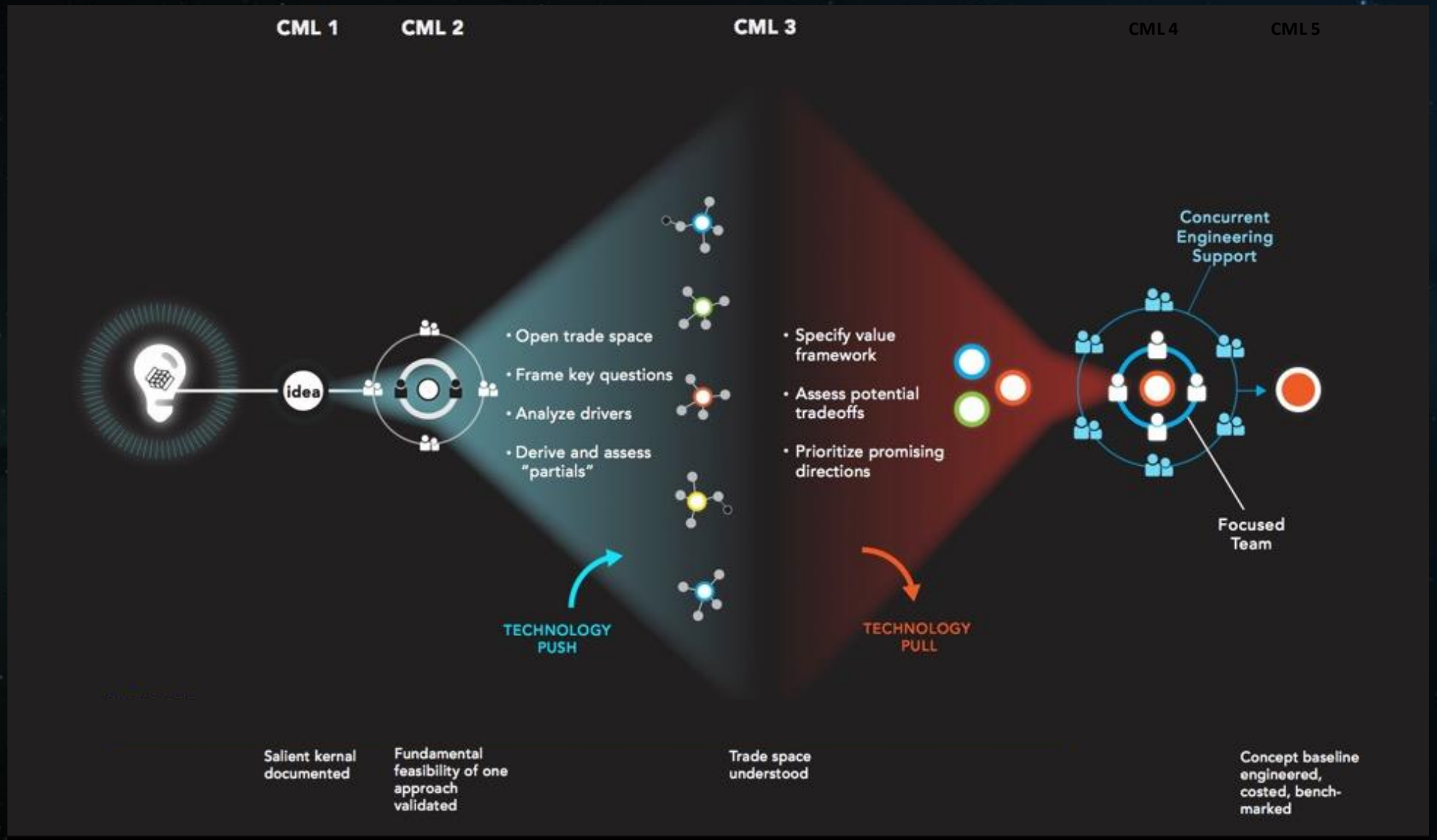
Using CMLs helps concept teams understand the work that needs to be done in parallel during pre-Phase A

- The Large Mission Study Report recommended using CMLs and SMD is studying how they can be incorporated into NASA's practices

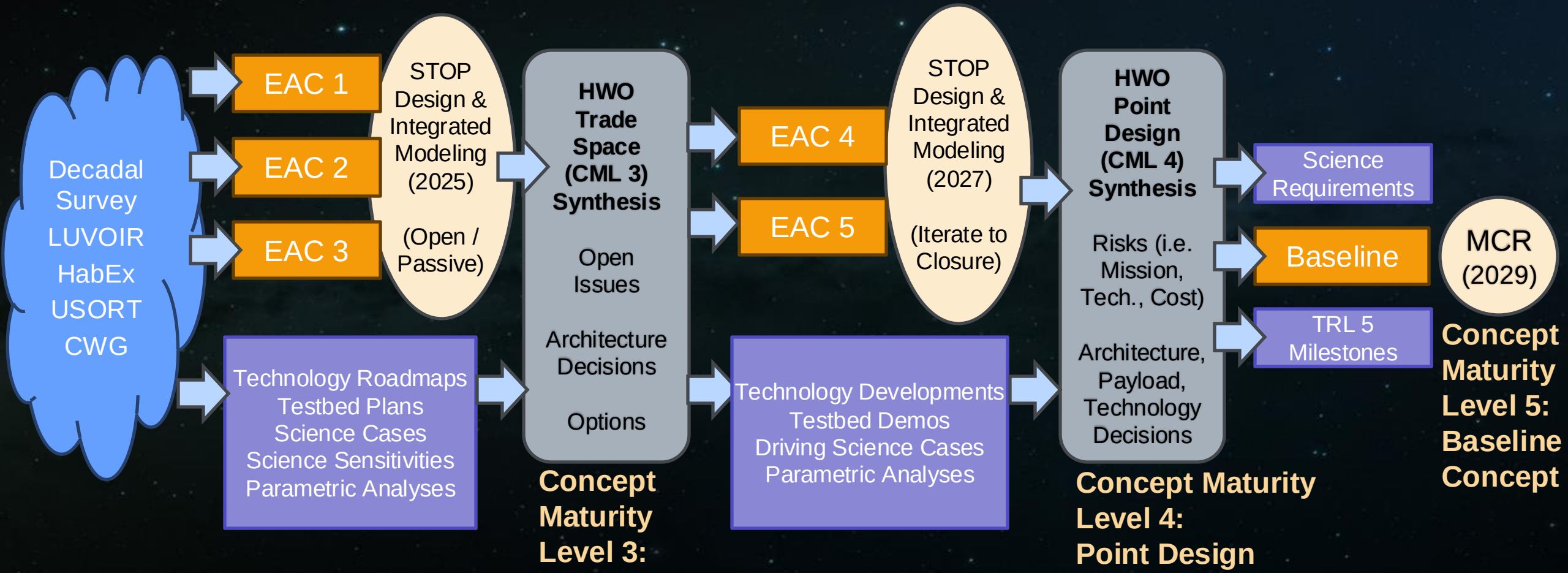
Each of the six dimensions of concept maturity has its own set of expected status and evidence at each CML

If any one dimension gets ahead or is not connected to the others, ideas and requirements can become "locked in" too early, causing rework

EXPLORING THE TRADE SPACE THROUGH CMLS



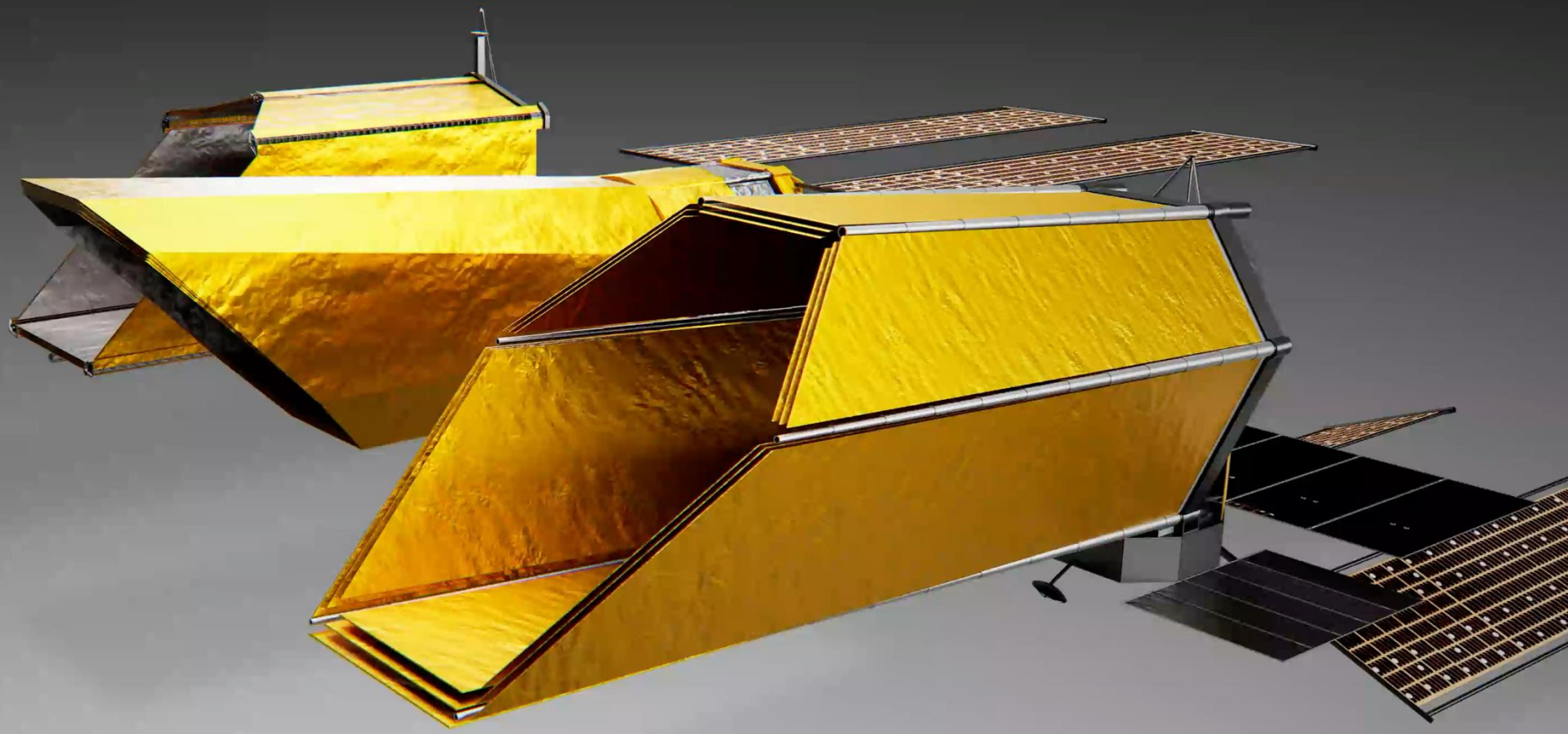
HWO Concept Maturation :
Iterate Exploratory Analytic Cases (EAC's), Science, Technology



CML – Concept Maturity Level
EAC – Exploratory Analytical Case
CEC – Coronagraph Exploratory Case
STO – Structure / Thermal / Optical

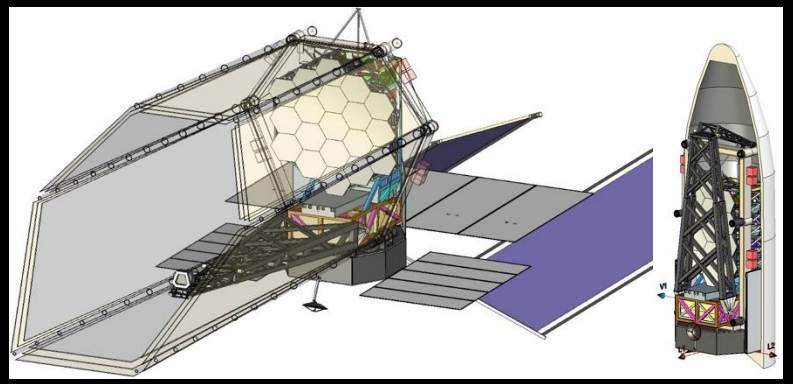
Exploratory Analytic Cases (EAC's)

Help us understand the trade space

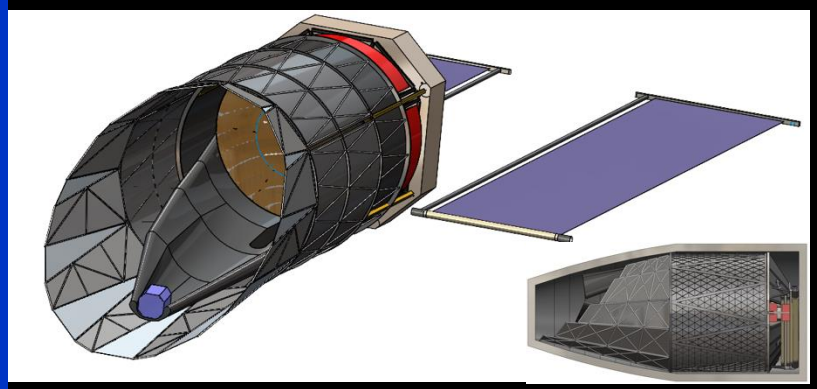


Notional Exploratory Analytic Cases

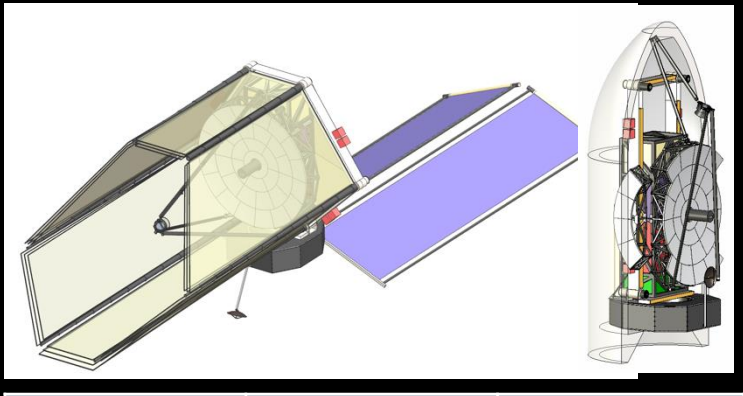
Note: Rocket approach is TBD



EAC1	Fairing Size Assumption	Comments
Launch Vehicle	New Glenn (or Starship)	7m diameter Fairing
Mass	Bottoms up estimate	
#of Mirrors	19 Hex Segments	1.65m point to point
Telescope Diam + Config	Off-Axis, 6M ID/7.2m OD	Starshade compatible
Deployment	JWST-like Wings,SM Hinged tower	



EAC2	Fairing Size Assumption	Comments
Launch Vehicle	Starship or Equivalent	9m diameter Fairing
Mass	Bottoms up estimate	
#of Mirrors	6+1	3m central mirror, 6 Keystone
Telescope Diam+Config	Off-Axis, 6m Circ.	Starshade compatible
Deployment	SM hinged, Barrel only	

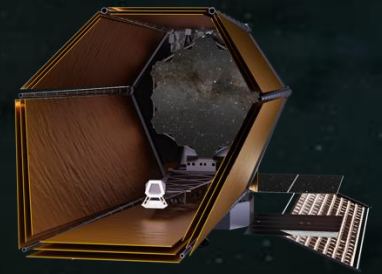


EAC3	Fairing Sizze Assumption	Comments
Launch Vehicle	Starship or Equivalent	9m diameter Fairing
Mass	Bottoms up estimate	
#of Mirrors	34 Keystone	
Telescope Diam+Config	On-Axis, 8m Circ.	Starshade compatible
Deployment	JWST-like Wing, SM	

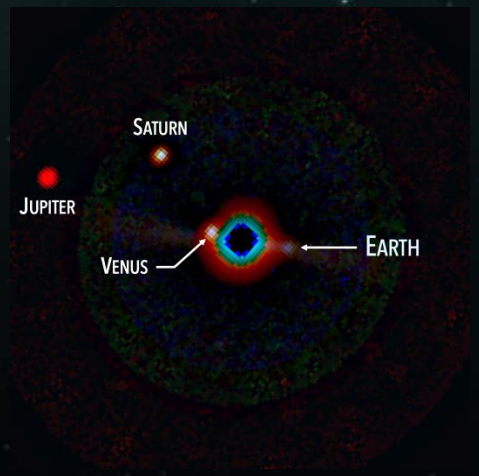
EAC2 Deployment (Example)

Preliminary specs & candidate instruments

Telescope	
Diameter	$\gtrsim$6.0 m
Bandpass	~100–2500 nm
Diff. Limit @	~500 nm



Coronagraph	
High-contrast imaging and imaging spectroscopy	
Bandpass	~350–1700 nm
Contrast	$\lesssim 1 \times 10^{-10}$
R ($\lambda/\Delta\lambda$)	Vis: ~140 NIR: ~70, 200



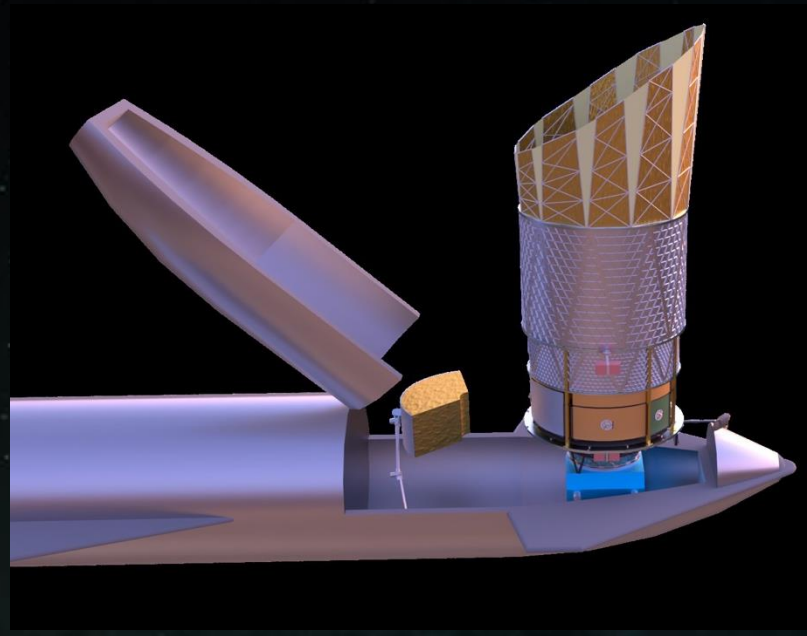
High-Resolution Imager	
UV/Vis and NIR imaging	
Bandpass	~200–2500 nm
Field-of-View	~$3' \times 2'$
60+ science filters & grism	
High-precision astrometry?	

UV Multi-Object Spectrograph	
UV/Vis multi-object spectroscopy and FUV imaging	
Bandpass	~100–1000 nm
Field-of-View	~$2' \times 2'$
Apertures	~840×420
R ($\lambda/\Delta\lambda$)	~500–50,000

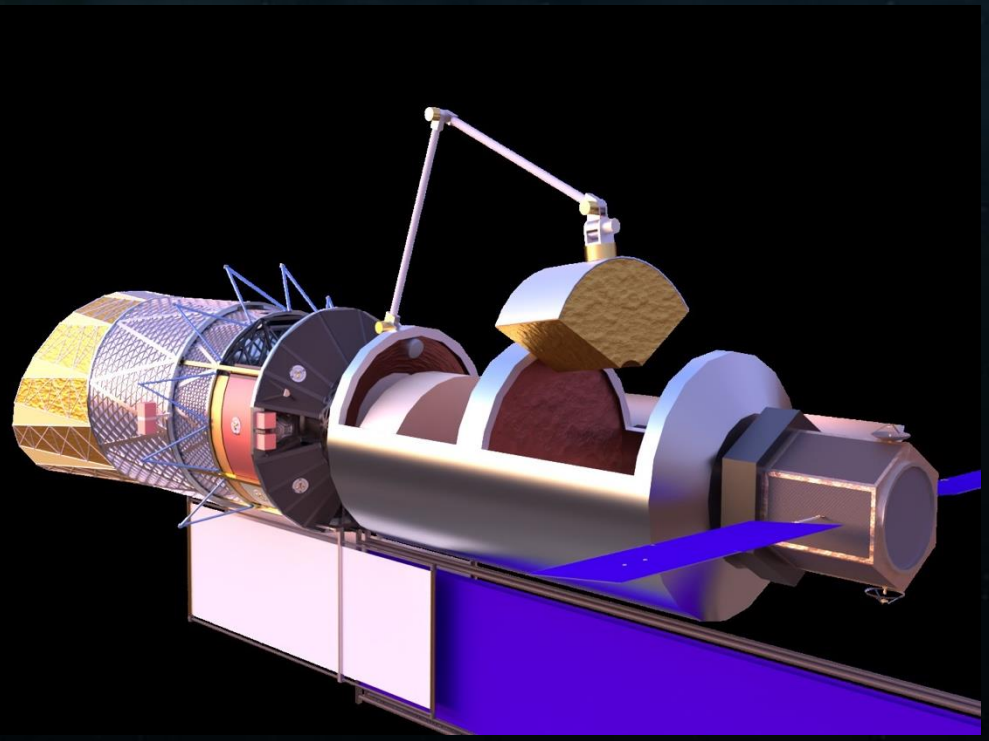
Fourth Instrument To be defined

Candidates include NUV Coronagraph, FUV IFS, UV Spectropolarimeter

IN-SPACE SERVICING CONCEPT



Servicing Concepts with EAC2 Example

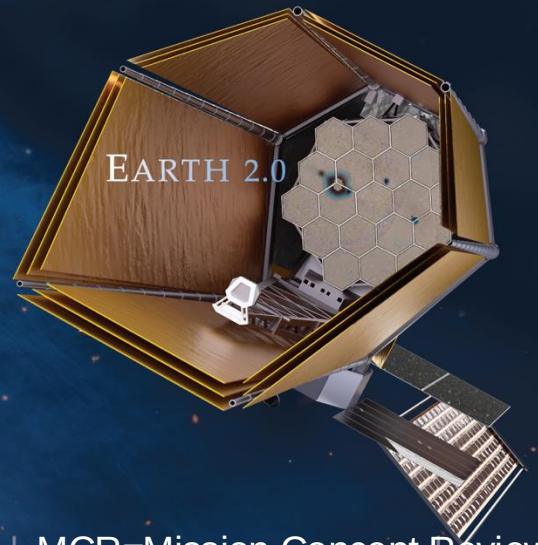


Robotic Serviceability

- Allows multiple generations of Instruments
- Enables earlier launch date by focusing on minimum needs initially
- Architecting for Serviceability helps Integration and Testing
- Needs to be implemented early

HABITABLE WORLDS OBSERVATORY

Habitable Worlds Observatory Plan to MCR



MCR=Mission Concept Review
EAC=Exploratory Analytic Case

Community Science and Instrument Team and HWO Advisory Board

Concept Maturity Level-3 EAC 1-3 complete

Science + Technology Conference

HWO Journal Special Editions

Concept Maturity Level-*4* EAC *4,5* complete

Science Drivers Draft L1 Requirements

Concept Maturity Level-5 (EAC6/Baseline Concept)

Draft Science Cases

05/25 07/25 08/25

Define EAC 4,5

Instrument Studies Start

Define EAC 6/ Baseline Concept

03/29

06/29 Independent Technical Review

10/29 MCR

2025 *2026* *2027* *2028* *2029* *2030*

Contingent on Funding

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

Coronagraph System

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

Currently Funded | Development / Fabrication

Design and Analysis | Characterization / Demonstration

High-Sensitivity UV & Instrument Technologies

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

*Contingent on Funding

HWO TECHNOLOGY DEVELOPMENT

NASA ROSES 2017

System-Level Segmented Telescope Design (SLSTD)

NNH17ZDA001N-SLSTD

NASA ROSES 2019

SLSTD – Technology Maturation

NNH19ZDA001N-SLSTD

NASA ROSES 2023

Critical Technologies for Large Telescopes

NNH23ZDA001N-CT4LT

NASA ROSES 2025 (Offers Due: 2/6/2025)

HWO System Technology Demonstrations and Mission Architecture Studies

NNH24ZDA001N-HWOTAS

ROSES SAT AND APRA

Numerous funded efforts in coronagraphy, UV technology , detectors, etc

Current open APRA and SAT Calls are HWO focused

JATIS SPECIAL EDITION FOR HWO

Habitable Worlds Observatory Pre-Formulation Science, Architecture Concepts, and Technology Maturation

Submissions open: 1 June through 1 September 2025.
Publication Date: April-June 2026
Guest Editors: Lee Feinberg, Michael McElwain, Betrand Mennesson

Timed to allow HWO Science and Technology Conference Talks and Posters to be submitted here

Papers are solicited in the following areas of interest:

- Architecture early analytic concepts
- Coronagraph system technologies
- Ultrastable telescope system technologies
- High-sensitivity UV and visible instrumentation
- Integrated modeling, including technical and scientific performance
- Servicing

Summary

- New Project Office is up and running
- The TMPO plan includes evaluating the science, architecture and technology iteratively as was recommended in the national academy recommendation
- Join the HWO community!