

National Aeronautics and  
Space Administration



# 2024 NASA SCIENCE

**Habitable Worlds  
Observatory**

**Megan Ansdell  
HWO Program Scientist**

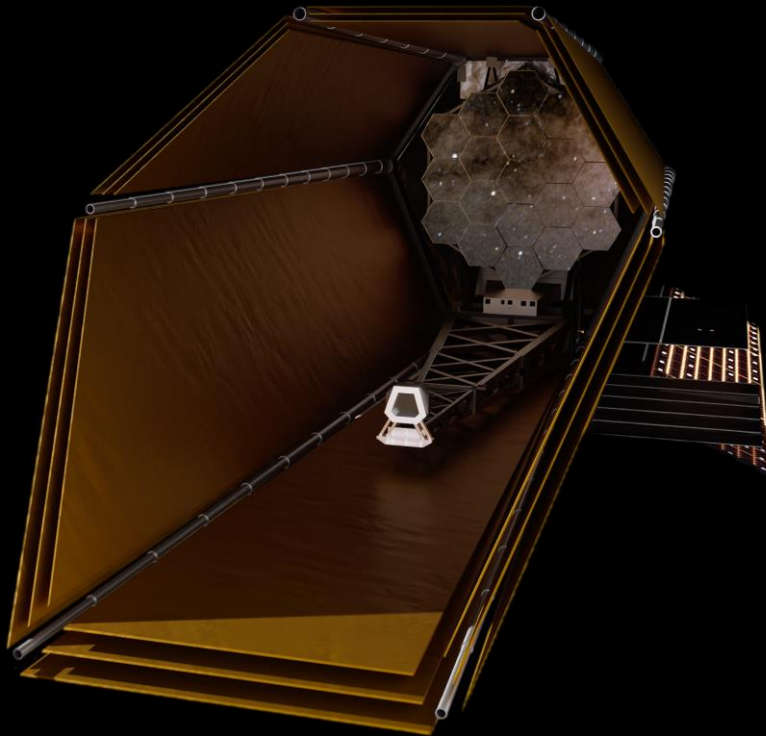




# Habitable Worlds Observatory

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

Large-aperture  
**IR / VIS / UV**  
space-based  
observatory



**First telescope** designed specifically to **search for signs of life** on planets outside our solar system

# Astro2020 Decadal Survey



“...[the] same **large aperture telescope** that can **identify Earth analogs** would be equally transformative for general astrophysics...”

“...would inherit the scientific **power of HST**, but...**1-2 orders of magnitude leaps** in sensitivity & performance...”

“...**breakthrough** discoveries across nearly **all of astrophysics**...one of the **most scientifically versatile** astronomical telescopes ever flown...”

# Astro2020 Decadal Survey

Finding: For a decadal survey to confidently recommend implementation of a strategic mission as its highest priority, the mission's technology and architecture need to be **developed to a level of maturity that allows a reasonable assessment of budget profile, scientific performance, and technology risk.** The mission's cost range and development time scale must be deemed appropriate for the scientific scope.

Conclusion: Enabling subsequent decadal surveys to recommend mission implementations with sufficient knowledge of the feasibility, overall budgetary needs, and time scale **requires significant investment toward maturing large strategic mission science, technologies, and architecture in an integrated way.**

## Recommendation:

The NASA Astrophysics Division should **establish a Great Observatories Mission and Technology Maturation Program**, the purpose of which is to co-develop the science, mission architecture, and technologies for NASA large strategic missions identified as high priority by decadal surveys [**First entrant: IR/O/UV observatory**].

- ★ Co-develop the mission science, technology, and architecture
- ★ ... earlier in the mission concept development phase
- ★ ... to a Concept Maturity Level (CML) that allows for more robust assessments of cost, performance, risk

# HWC: Implementing Lessons Learned for Large Missions

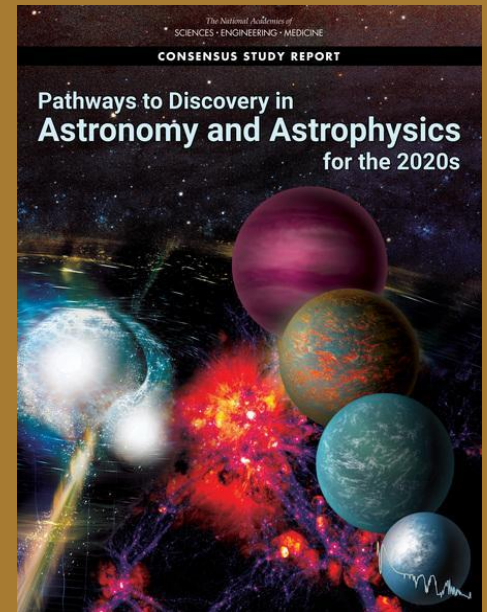
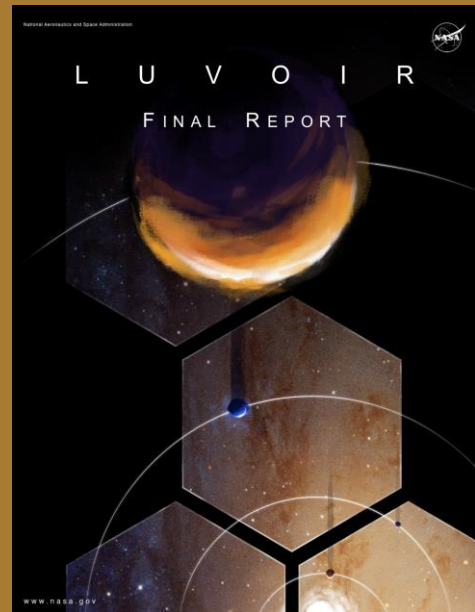
Independent Research Papers

Mission Concept Reports

GAO Report on Major Projects

NASA SMD Internal Studies

National Academy Reports



- ★ Co-develop the mission science, technology, and architecture
- ★ ... earlier in the mission concept development phase
- ★ ... to a Concept Maturity Level (CML) that allows for more robust assessments of cost, performance, risk

# Decadal Survey → Big Picture Strategy

## ★ Build to Schedule

*Mission Level 1 requirement  
(as for planetary missions)*

## ★ Evolve Technologies & Architectures

*Build on NASA investments & TRL-9 technology  
→ JWST: segmented optical telescope system  
→ Roman: coronagraph from CGI program*

## ★ Mature Technologies First

*Reduce risk by fully maturing technologies  
prior to mission development phase*

## ★ Use Next Generation Rockets

*Needed for large telescope aperture sizes  
Leverage opportunities for mass & volume trades*

## ★ Plan for Servicing

*Maintain ability for robotic servicing at L2*

## ★ Design with Robust Margins

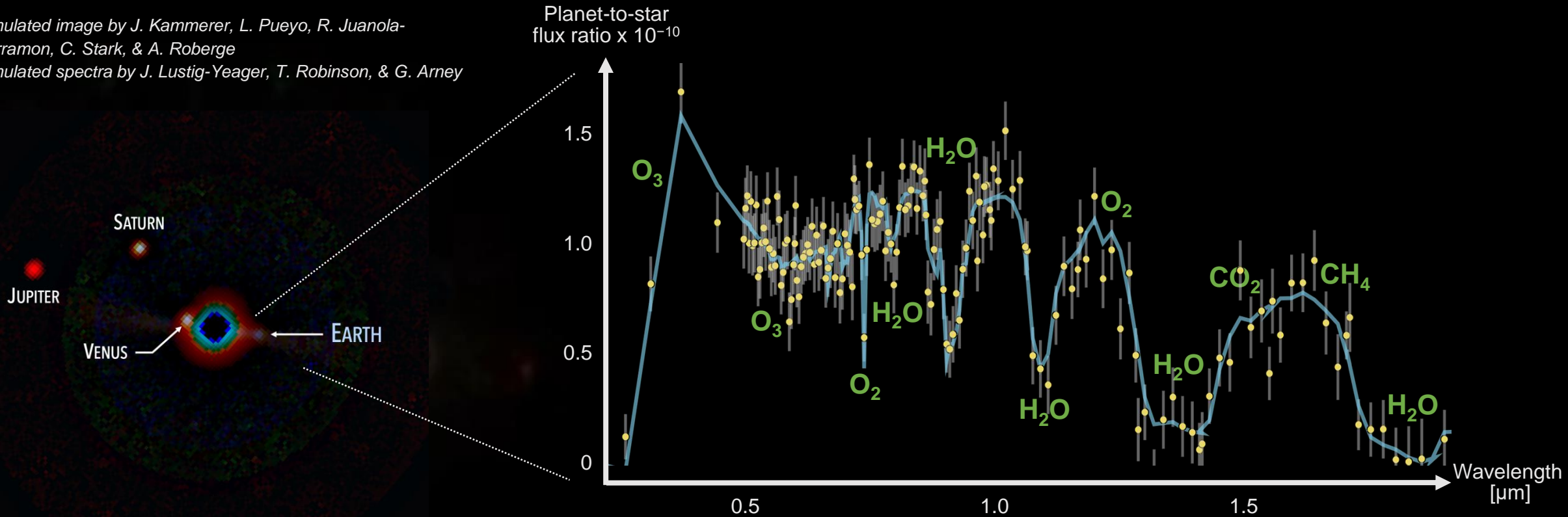
*Scientific, technical, and programmatic margins*



# HWO: Searching for Life Outside the Solar System

*Simulated image by J. Kammerer, L. Pueyo, R. Juanola-Parramon, C. Stark, & A. Roberge*

*Simulated spectra by J. Lustig-Yeager, T. Robinson, & G. Arney*

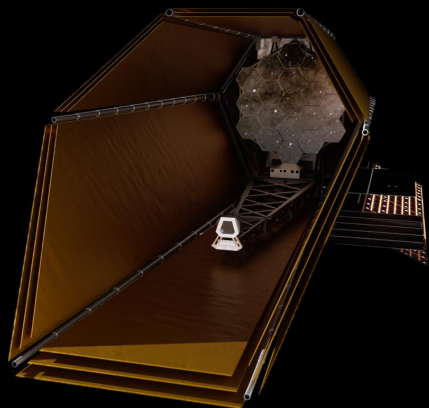


*HWO will directly image at least ~25 Earth-sized exoplanets in the Habitable Zones around Sun-like stars, by suppressing starlight by factors of ~10 billion to obtain exoplanet atmosphere spectra covering multiple potential biosignatures*

# HWO: Preliminary Specs + Candidate Instruments

## Telescope

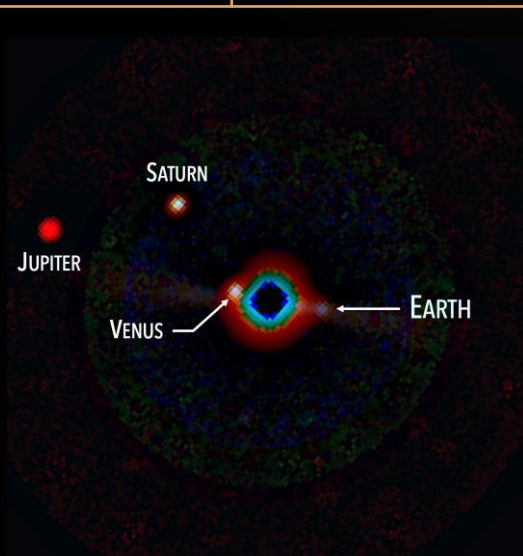
Diameter	~6.0 m (inner)
Bandpass	~100–2500 nm



## Coronagraph

High-contrast imaging and imaging spectroscopy

Bandpass	~200–1800 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' × 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' × 2'
Apertures	~840 × 420
R ( $\lambda/\Delta\lambda$ )	~500–60,000

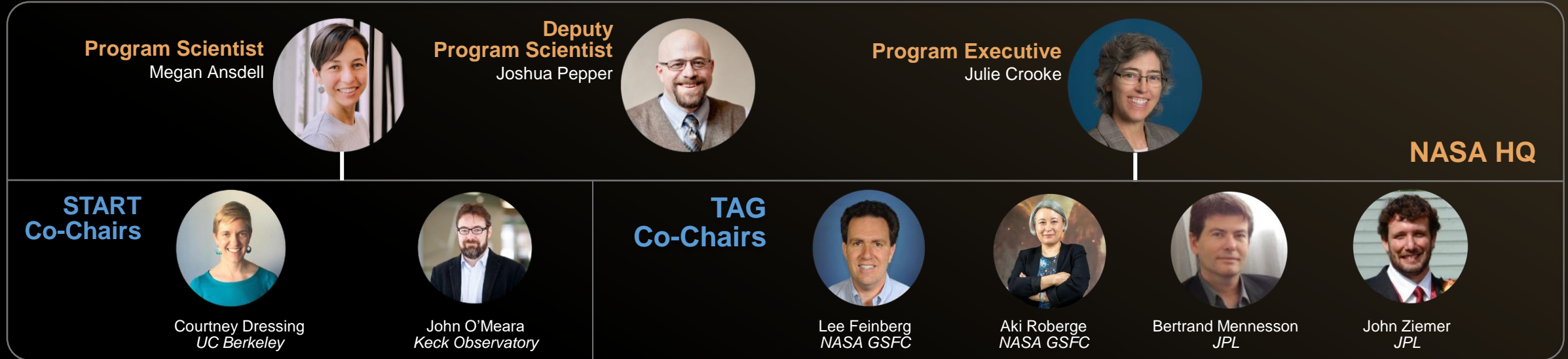


**Fourth Instrument**  
TBD

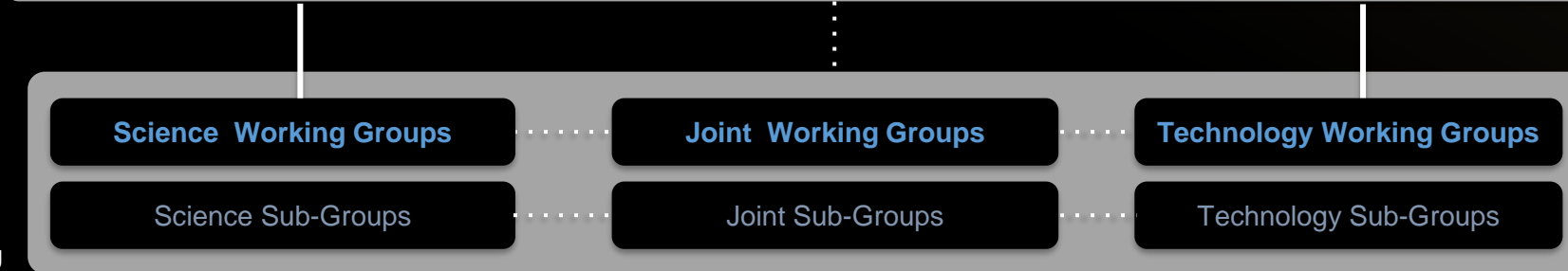


# HWO: Organization\*\*

## HWO Leadership Team



*Selected members including ex-officios representing NASA Astrophysics Program Offices, industry, and international partners*



*Open community Working Groups and Sub-Groups supporting START/TAG activities*

— Reporting  
- - - Coordinating

# START

SCIENCE, TECHNOLOGY, ARCHITECTURE REVIEW TEAM

## PURPOSE

- Primarily **science-oriented** group
- Explore & develop possible science cases

## MEMBERSHIP

- 23 from academia, institutes, NASA Centers, JPL
- 3 ex-officio from NASA Astrophysics Program Offices
- 4 ex-officio from **industry**
- 6 ex-officio from **international** partners

# TAG

TECHNICAL ASSESSMENT GROUP

## PURPOSE

- Primarily **engineering-oriented** group
- Explore & develop technology & architecture options

## MEMBERSHIP

- 27 from NASA & JPL (**government only**)
- 3 ex-officio from NASA Astrophysics Program Offices

- ★ *Members of the START & TAG groups were selected from self-nominations & announced in September 2023*
- ★ *START & TAG guide the wider HWO community efforts through the HWO Working Groups, which are open to all*
- ★ *These efforts focus on trade space exploration & development; no decisions, down-selections, etc. are made*

# HWO: Community Working Groups

## START / SCIENCE

Galaxy Growth

Solar System in Context

Living Worlds

Evolution of Elements

## COMMUNITY

Ground-Based Astronomy  
in the 2030s/2040s

Synergies  
for Future Missions

Inclusion & Mentorship

Space-Based Astronomy  
in the 2030s/2040s

Communications

## JOINT

Science-Engineering Interface

Science Case Simulation

Science Data Simulation

Machine  
Learning

Past Studies  
Comparison

## TAG / TECHNOLOGY

Systems

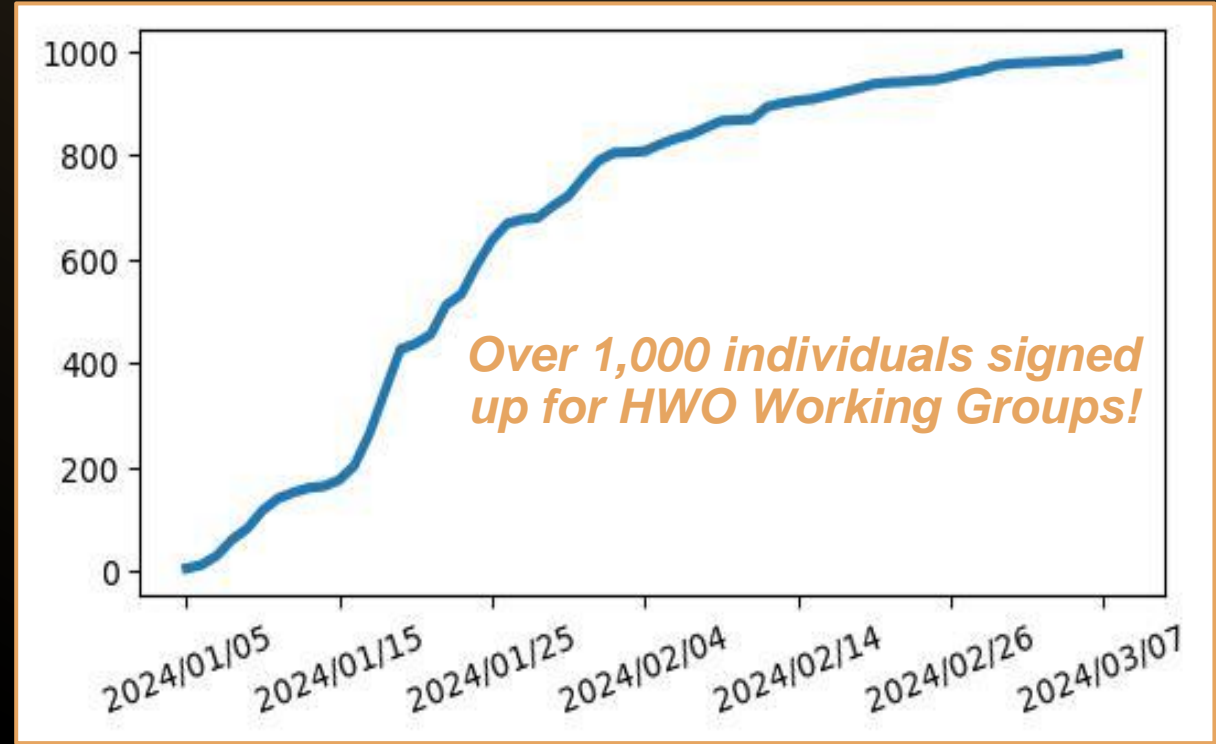
Integrated Modeling

Technology

Servicing



# HWO: Community Working Groups



American Astronomical Society (AAS) Winter Meeting  
HWO Splinter Session  
- Jan. 2024, New Orleans

# HWO: Community Working Groups

## START / SCIENCE

Galaxy Growth

Solar System in Context

Living Worlds

Evolution of Elements

## COMMUNITY

Ground-Based Astronomy  
in the 2030s/2040s

Synergies  
for Future Missions

Inclusion & Mentorship

Space-Based Astronomy  
in the 2030s/2040s

Communications

## JOINT

Science-Engineering Interface

Science Case Simulation

Science Data Simulation

Machine  
Learning

Past Studies  
Comparison

## TAG / TECHNOLOGY

Systems

Integrated Modeling

Technology

Servicing

*HWO working groups & sub-groups are co-chaired  
by START/TAG members & community members*



# HWO: F2F Meetings



HWO START/TAG Kick-Off - Fall 2023, DC

HWO START/TAG + Working Group Co-Chairs - Spring 2024, Pasadena



HWO START/TAG + Working Group & Sub-Group Co-Chairs - Summer 2024, Baltimore

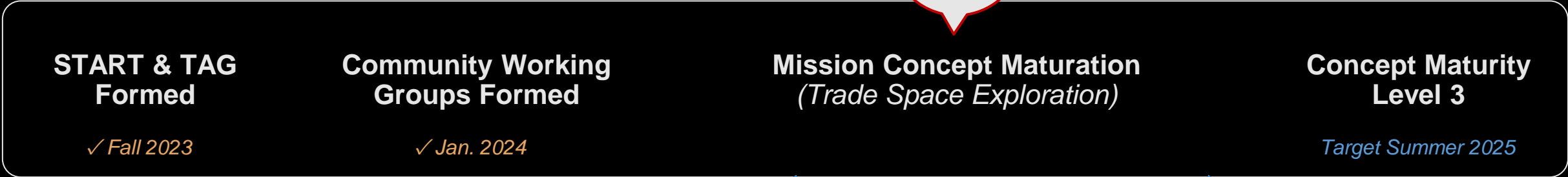


**2024 Fall F2F Meeting – Oct. 22-24, 2024**

Rochester, NY & Online



# HWO: Milestones



## ACTIVITIES



# HWO: FY24 Budget

## FY24 Conference Language Report

*The Senate Report language regarding “Habitable Worlds Observatory” is adopted and the agreement provides **no less than \$10,000,000** for the mission. In addition, the agreement directs NASA to establish a Habitable Worlds Observatory **project office at Goddard** Space Space Flight Center to leverage expertise in astrophysics and segmented mirror technology.*

## Senate Report Language

*The Committee **supports the Great Observatory Maturation Program (GOMAP)** as recommended by the Decadal Survey on Astronomy and Astrophysics, “Pathways to Discovery in Astronomy and Astrophysics for the 2020s” [Astro2020]. GOMAP will **mature science and technologies** needed for future flagship missions starting with the Habitable Worlds Observatory to observe habitable exoplanets. In order to cement continued American leadership in astronomy, the Committee provides the requested level for GOMAP to implement the Astro2020 recommendations. NASA is encouraged to articulate funding for GOMAP separately in future budget requests.*

# HWO: Organization

## NASA HQ Leadership

Program Executive



Julie Crooke

Program Scientist



Megan Ansdell

Deputy Program Scientist



Joshua Pepper

## HWO Technology Maturation Project Office (TMPO) Leadership

Principal  
Architect



Lee Feinberg  
GSFC

Project  
Manager  
*(interim)*



J. Scott Smith  
GSFC

Mission System  
Engineer



Mike Menzel  
GSFC

Project  
Scientist  
*(interim)*



Giada Arney  
GSFC

Pre-formulation  
Scientist  
*(interim)*



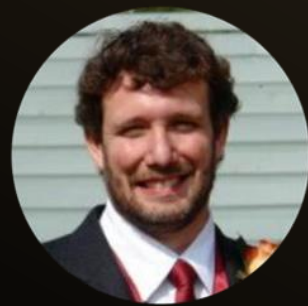
Aki Roberge  
GSFC

Pre-formulation  
Scientist  
*(ex-officio)*



Bertrand Mennesson  
JPL

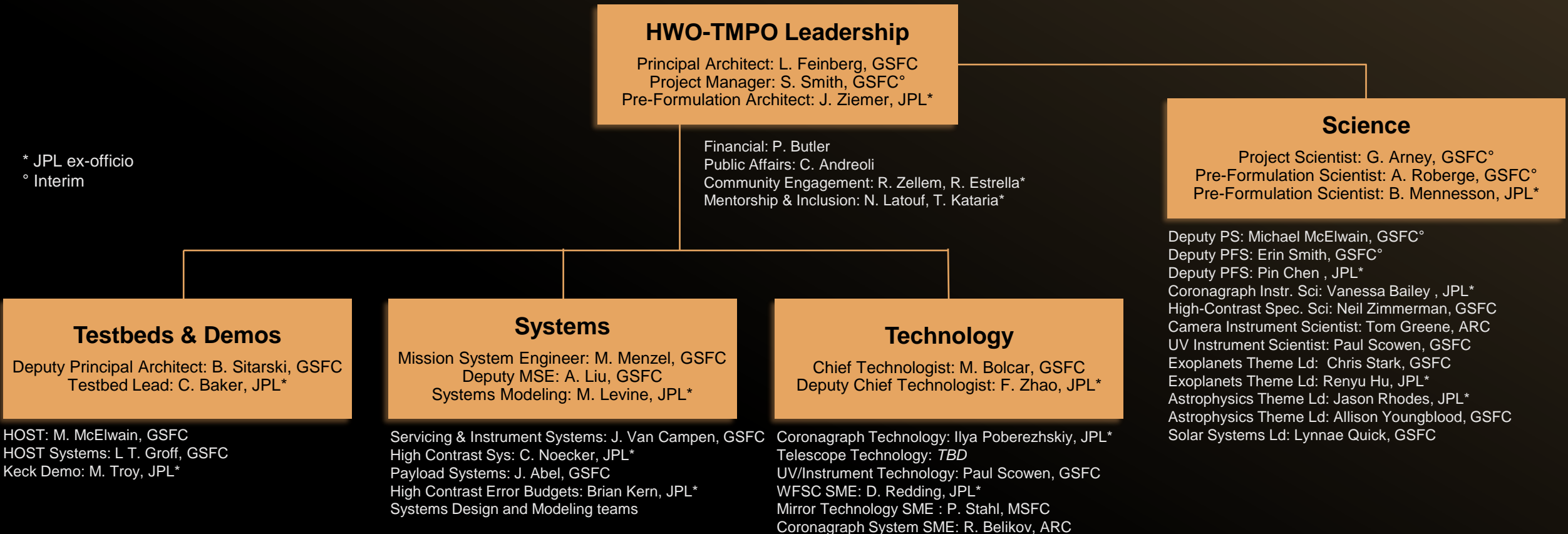
Pre-formulation  
Architect  
*(ex-officio)*



John Ziemer  
JPL

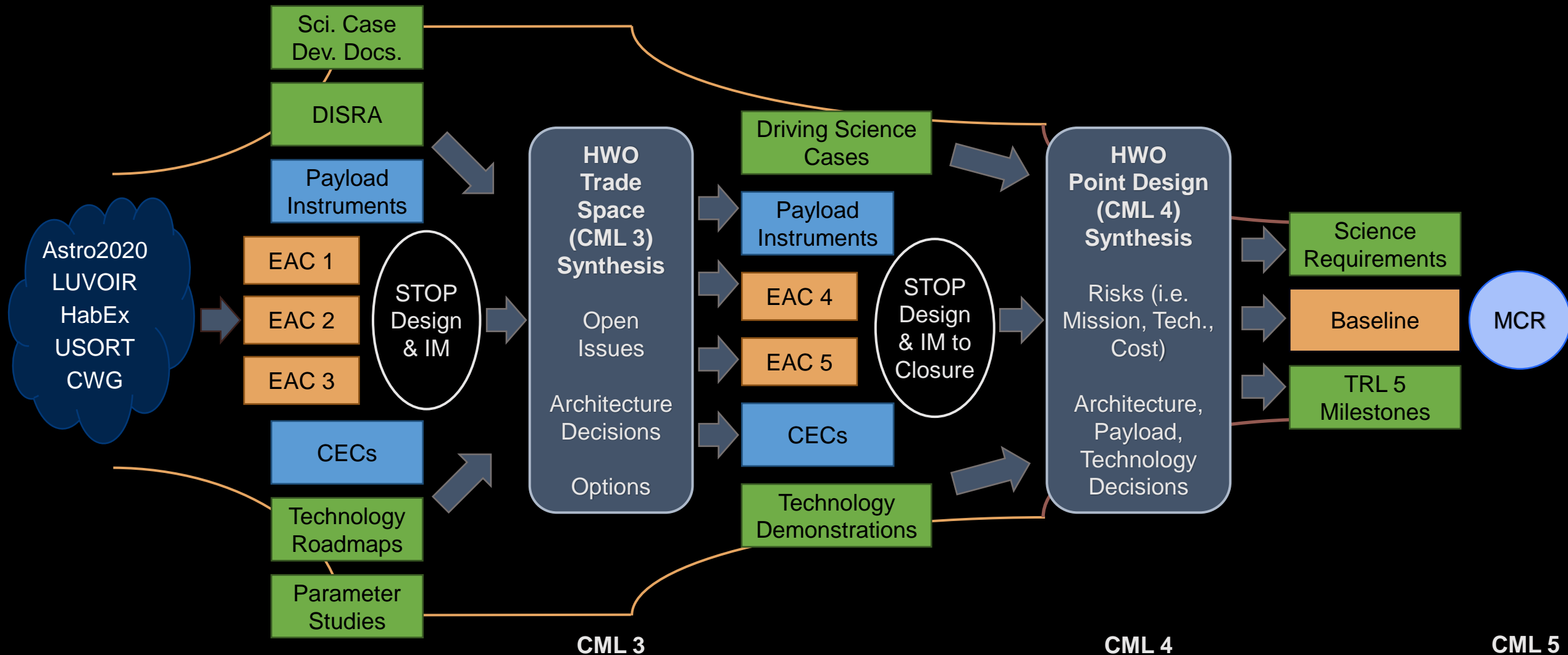


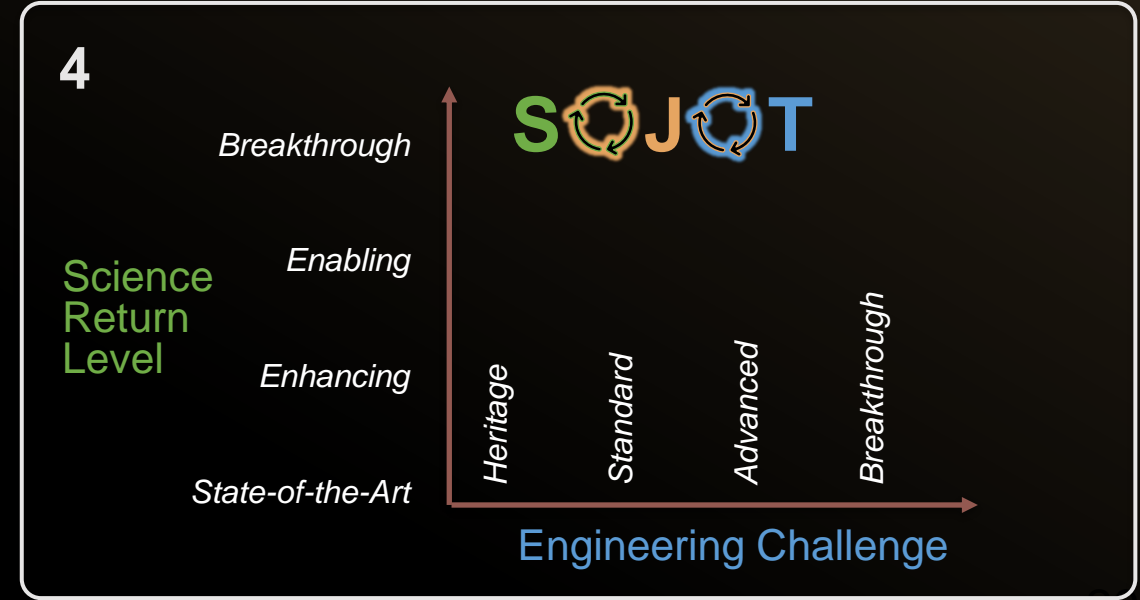
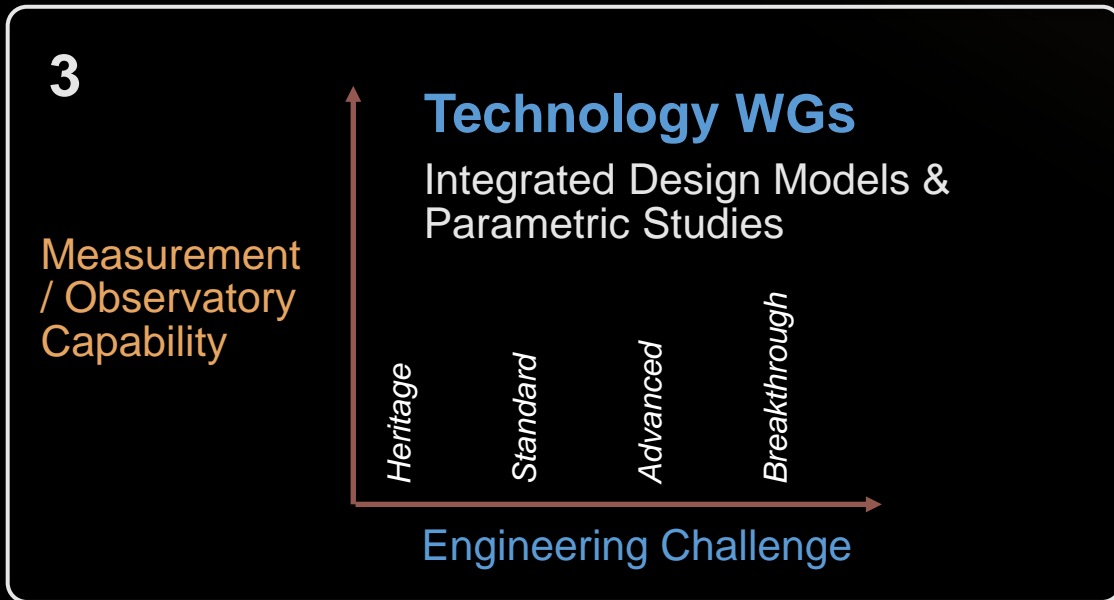
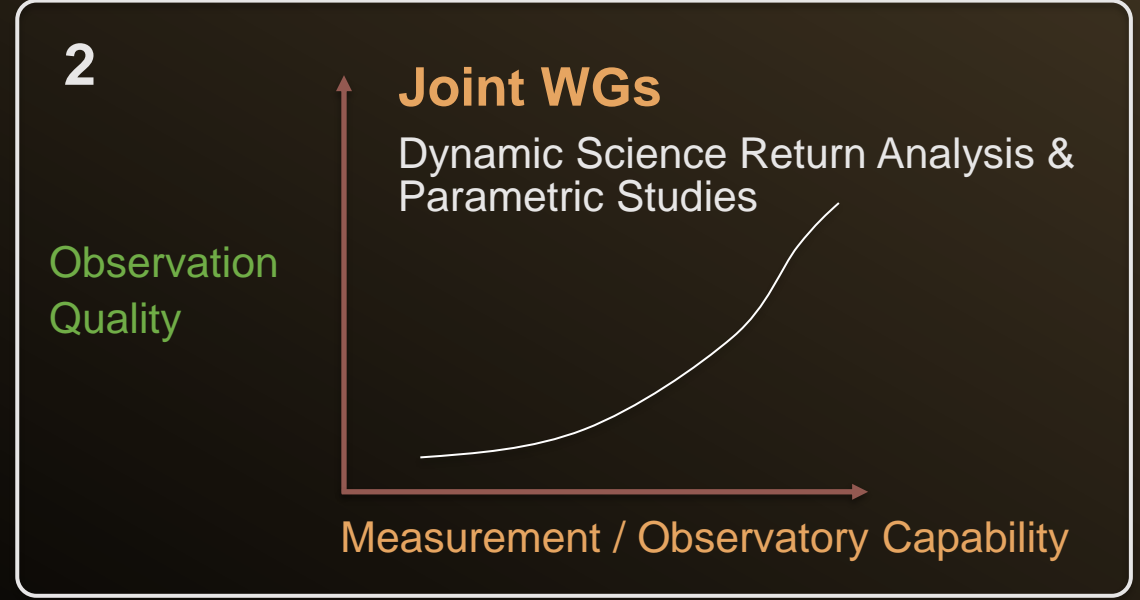
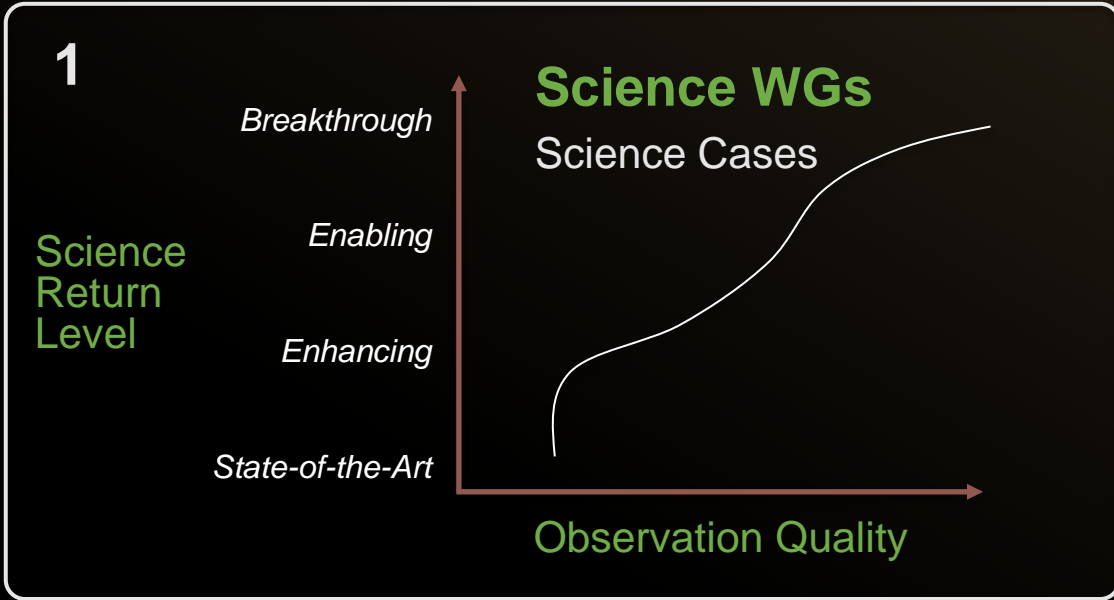
# HWO: Technology Maturation Project Office (TMPO)



*The Pre-Formulation Project Development Team will encompass a broad group, including members from the former START/TAG, other NASA Centers, and JPL*

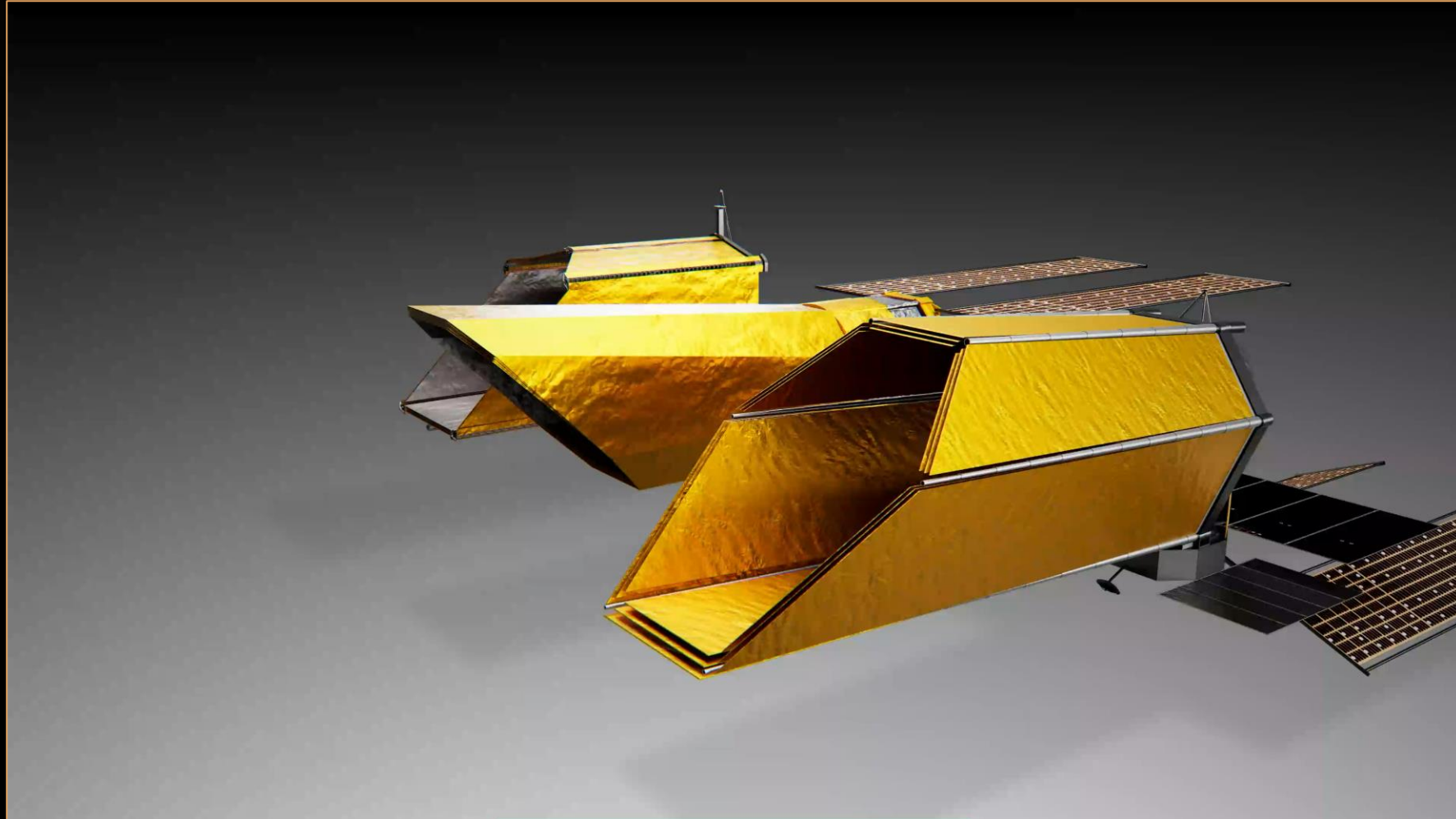
# HWO: Continuing to follow Astro2020 by iterating between Science, Architecture & Technology



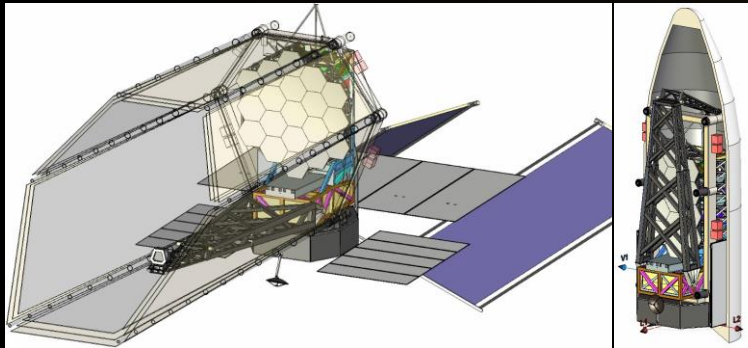




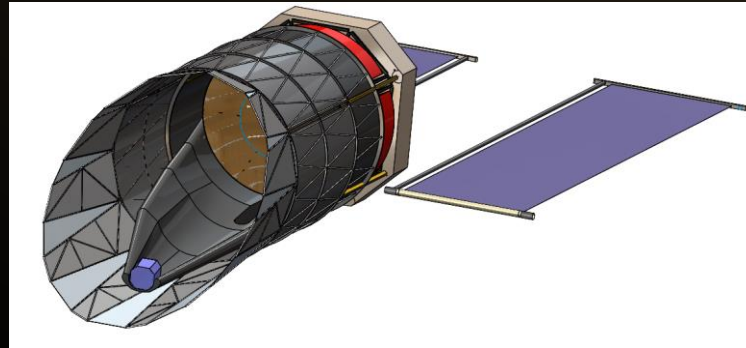
# HWO: Exploratory Analytic Cases (EACs)



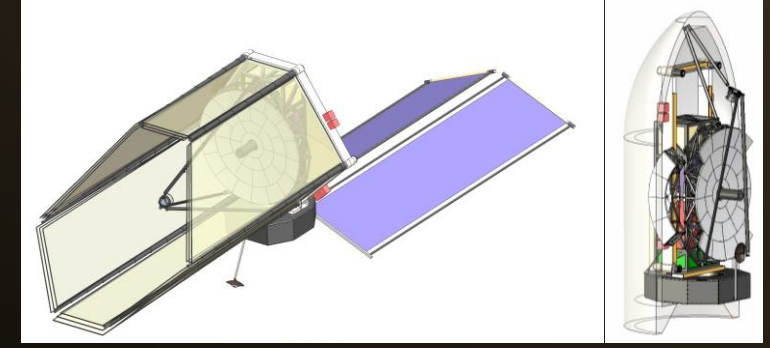
# HWO: Exploratory Analytic Cases (EACs)



EAC #1	Assumption	Comments
Launch Vehicle	<i>New Glenn</i>	<i>7m diameter Fairing</i>
Mass	<i>Bottoms up estimate</i>	
# Mirrors	<i>19 Hex Segments</i>	<i>1.65m point to point</i>
Telescope Diam + Config	<i>Off-Axis, 6m ID / 7.2m OD</i>	
Deployment	<i>JWST-like Wings, Hinged tower</i>	



EAC #2	Assumption	Comments
Launch Vehicle	<i>New Glenn or Starship</i>	<i>9m diameter Fairing</i>
Mass	<i>Bottoms up estimate</i>	
# Mirrors	<i>6+1</i>	<i>3m central mirror, 6 Keystone</i>
Telescope Diam + Config	<i>Off-Axis, 6m Circ.</i>	
Deployment	<i>SM hinged, Barrel only</i>	



EAC #3	Assumption	Comments
Launch Vehicle	<i>New Glenn or Starship</i>	<i>9m diameter Fairing</i>
Mass	<i>Bottoms up estimate</i>	
# Mirrors	<i>34 Keystone</i>	
Telescope Diam+Config	<i>On-Axis, 8m Circ.</i>	<i>Large FOV Hybrid OOFS Guider</i>
Deployment	<i>JWST-like Wing, SM</i>	

# TECHNOLOGY ROADMAP



2025

Coronagraph Testbeds Available For Use

Keck Sensing & Control Demo

Ultra-stable & System Testbeds Available For Use

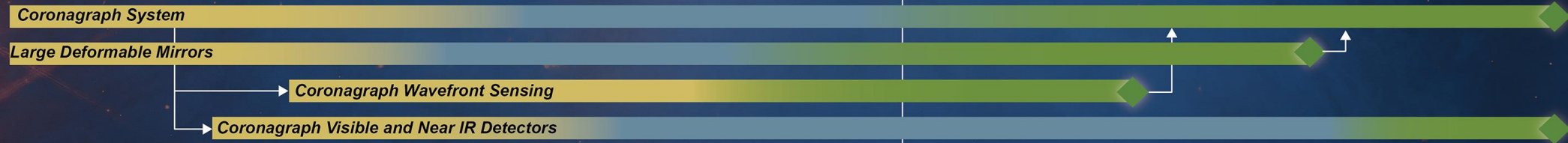
Critical Technology Demonstration Milestone

MCR

## Ultra-stable Telescope System



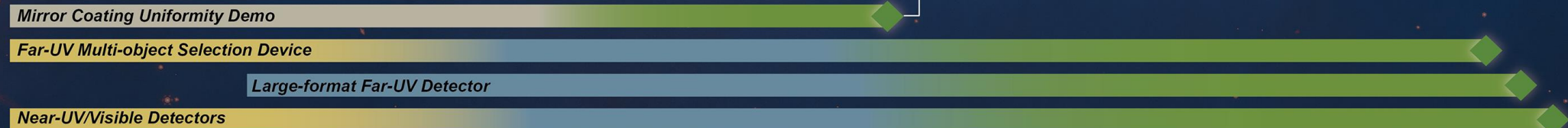
## Coronagraph System



Near-UV Coronagraph Science & Technology Investigation

Currently Funded	Development / Fabrication
Design and Analysis	Characterization / Demonstration

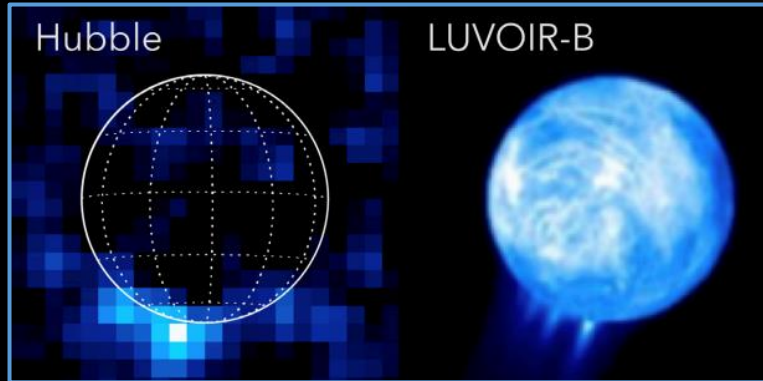
## High-Sensitivity UV & Instrument Technologies



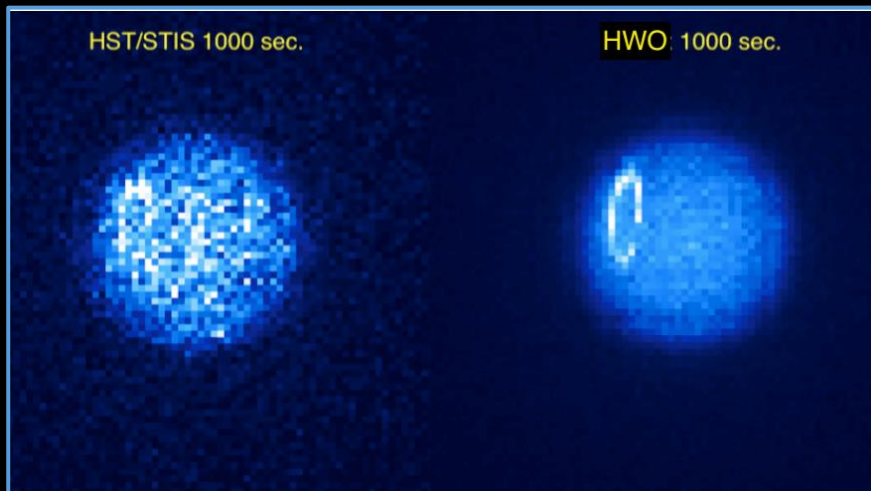


# HWO: Connections to Solar System Science

**Long-term monitoring** of solar system bodies at **UV/VIS/IR** to complement shorter-duration planetary missions



*Ex. UV/VIS/IR monitoring over multi-decade baselines with spectroscopy & imaging of surfaces, **exospheres & plumes** to constrain activity & composition for studying **habitability of interiors** (e.g., **Ceres, Europa, Ariel**) [LUVVOIR Final Report].*



*Ex. Extending HST & JWST studies of **planetary aurora** from **Jupiter & Saturn** to **Uranus & Neptune**.*

**Near-flyby quality observations** of objects **out to the Jupiter System**

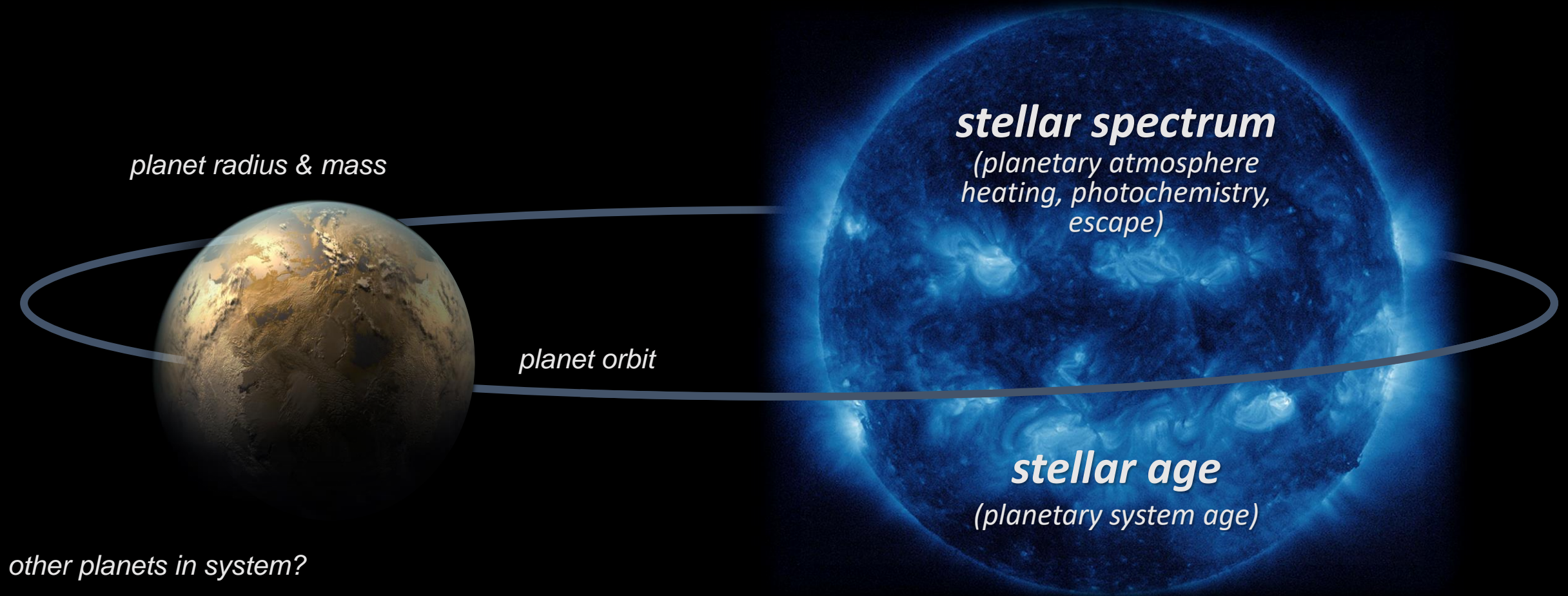


*Ex. Near fly-by quality observations of the **dwarf planet Ceres** [LUVVOIR Final Report].*



*Ex. Near fly-by quality observations of **Pluto** [LUVVOIR Final Report].*

# HWO: "Know Thy Star"





# HWO: Mentorship & Coaching Opportunities



## HWO Internships via NASA OSTEM

*Traditional project-based mentoring via NASA OSTEM with HWO-sponsored projects and HWO-affiliated mentors*



## HWO Projects via NASA MOSAICS

*Developing sustainable relationships with institutions historically under-resourced by NASA through the NASA MOSAICS program*



## HWO Mentorship & Coaching Program

*Coming Soon!*

*HWO Mentorship & Coaching Program being developed by the HWO Inclusion & Mentorship Working Group with HWO TMPO*



## ★ HWO continues to follow the Astro2020 Decadal Survey

*Co-maturing the mission science, architecture, and science via the HWO community working groups & planning of pre-formulation activities by the HWO Technology Maturation Project Office*

## ★ Attend upcoming HWO meetings

*AGU – HWO Town Hall (12/11 6-7pm) & Planetary Science and Astrobiology with HWO (12/13, 10am-12pm)  
AAS – HWO Splinter + Special Sessions (dates/times TBD)  
HWO Summer Meeting (dates TBD)*

*Virtual participation is open to all & recordings are posted on NASA's HWO website  
<https://science.nasa.gov/astrophysics/programs/habitable-worlds-observatory/meetings/>*

## ★ Join the HWO Community Slack

*Anyone can join the HWO Community Slack & create new channels*

