

# The Habitable

## Worlds Observatory:

### Updates & Opportunities for Community Involvement

**John O'Meara (he/his; START Co-Chair)**

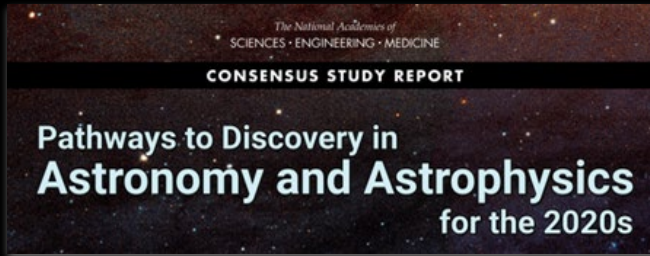
on behalf of the Great Observatory Maturation Program  
(GOMAP) Integration Group (GIG), Science Architecture  
Review Team (START), & Technical Assessment Group (TAG)



**COPAG**  
New Orleans, LA  
January 7, 2024

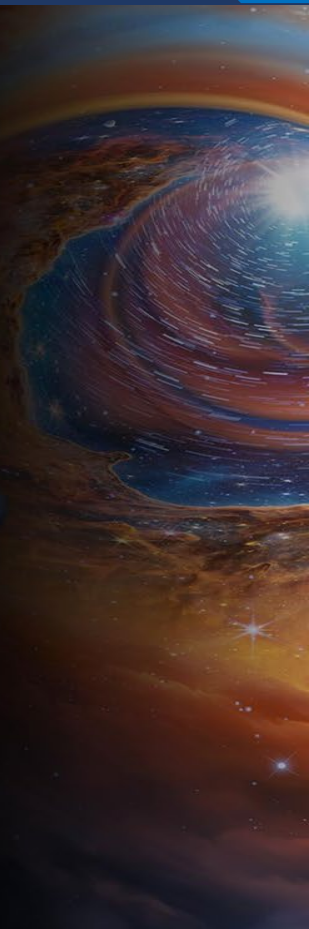
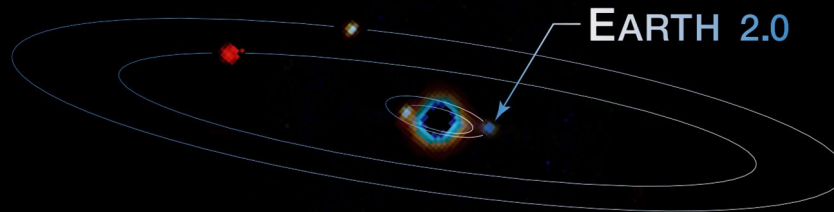
# Habitable Worlds Observatory (HWO)

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



Large IR/Opt/UV observatory performing transformative astrophysics

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





## NASA HQ Leadership

**Program Executive**



*Julie Crooke*

**Program Scientist**



*Megan Ansdell*

**Deputy Program Scientist**



*Josh Pepper*

**NASA GOMAP Website**



## Community START + TAG Leadership

**START Co-Leads**



*Courtney Dressing*  
UC Berkeley



*John O'Meara*  
W.M. Keck Observatory

**TAG Co-Leads**



*Lee Feinberg*  
GSFC



*Bertrand Mennesson*  
JPL

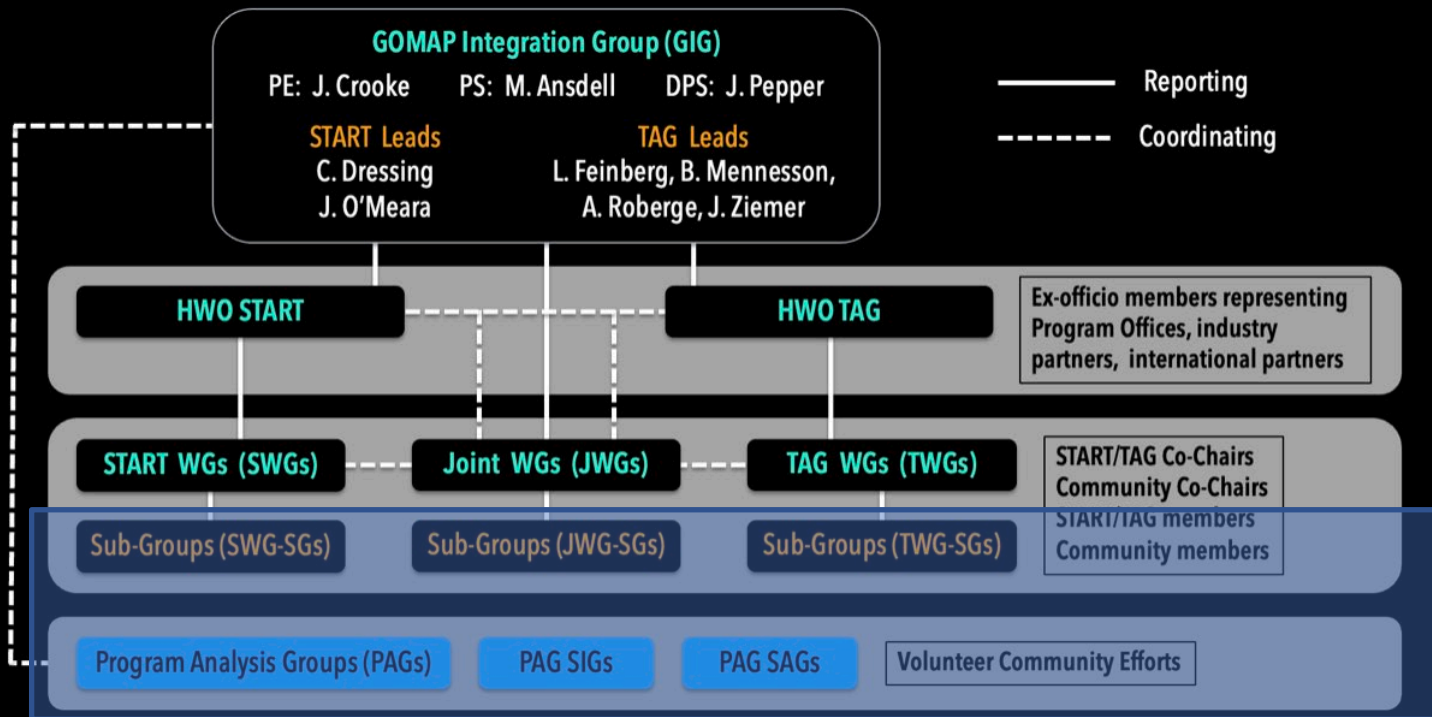


*Aki Roberge*  
GSFC



*John Ziemer*  
JPL

# Overall Structure



# The START & TAG Will Guide HWO Maturation

## Science, Technology, Architecture Review Team (START)

- Quantify HWO's science objectives using Astro2020's guidance
- Outline the observatory and instrument capabilities needed to accomplish those goals.
- Develop the science goals and objectives portions of the Science Traceability Matrix.
- Assess the fidelity of models needed in the future to execute future trades.

## Technical Assessment Group (TAG)

- Study architecture options.
- Identify and assess the mission architectures and technologies needed to enable those options.
- Evaluate the risks associated with those options.

# TAG Working Groups

- **Science-Engineering Interface**
- **Systems**
  - Starlight Suppression Error Budget
  - High-Contrast Post-Processing & ConOps
  - Starshade Compatibility
  - Computational Architecture
  - Integrated Modeling (may contain ITAR/EAR material)
- **Technology (includes ITAR/EAR material)**
  - Sensing & Control
  - Mirrors
  - Coronagraphs
  - Detectors
  - Artificial Intelligence/Machine Learning
- **Servicing**

# Science & Engineering Joint Working Groups

- **Comparison of Past Studies**
- **Science Case Simulation**
  - Exoplanet Direct Imaging Yields
  - Galaxy Evolution in the UV
  - Astrometry
- **Science Data Simulation**
  - High-Contrast
  - UV
  - Wide-field Imaging
- **Astronomy in the 2030s/2040s**
  - Space-based
  - Ground-based
- **Artificial Intelligence & Machine Learning**
- **GOMAP Synergies for Future Missions**

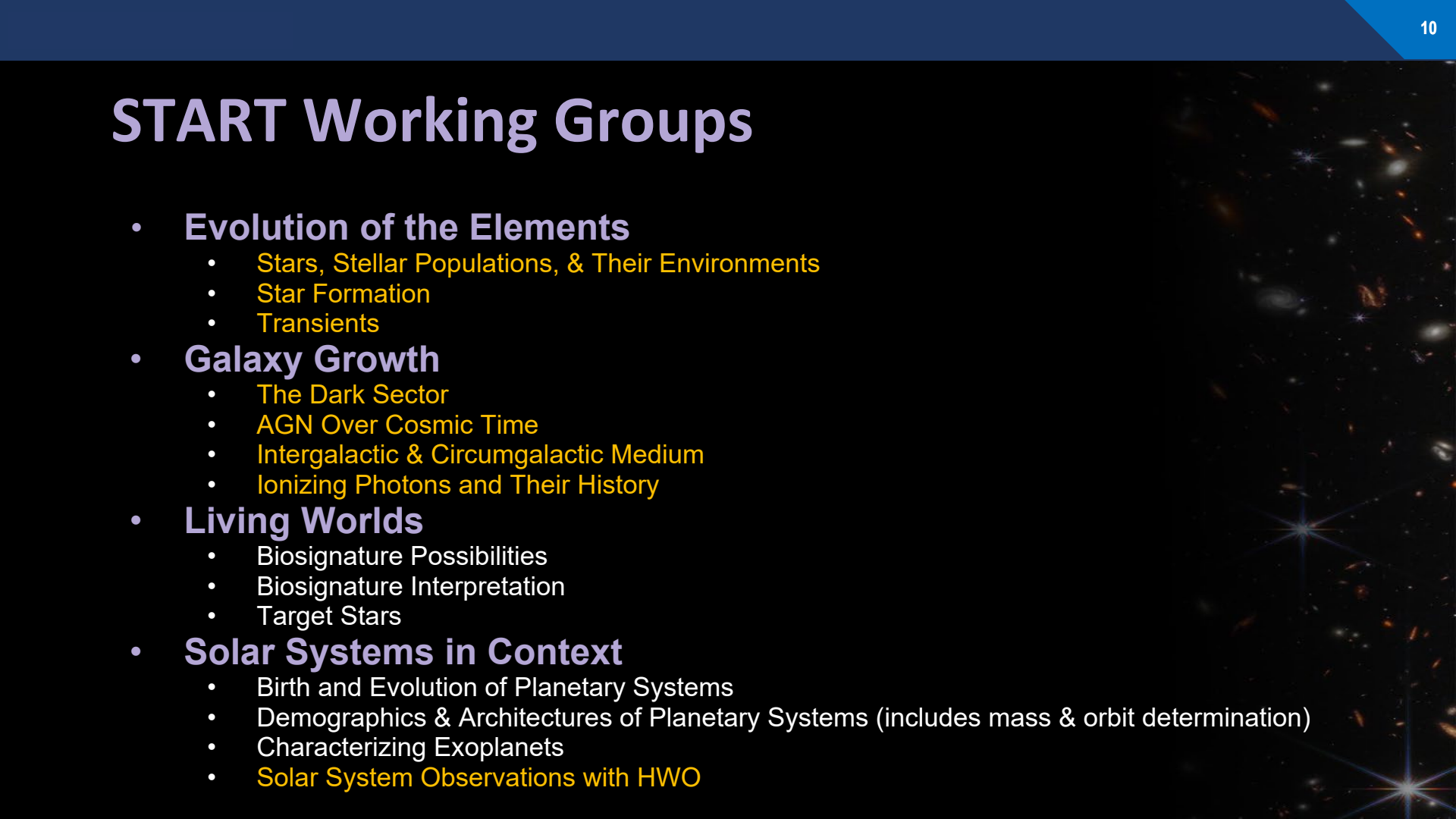


# Joint Working Groups

- **Diversity, Equity, Inclusion, & Accessibility**
- **Mentorship**
  - *The mentorship working group will initially be part of the DEIA working group.*
- **Communications**



# START Working Groups

- **Evolution of the Elements**
    - Stars, Stellar Populations, & Their Environments
    - Star Formation
    - Transients
  - **Galaxy Growth**
    - The Dark Sector
    - AGN Over Cosmic Time
    - Intergalactic & Circumgalactic Medium
    - Ionizing Photons and Their History
  - **Living Worlds**
    - Biosignature Possibilities
    - Biosignature Interpretation
    - Target Stars
  - **Solar Systems in Context**
    - Birth and Evolution of Planetary Systems
    - Demographics & Architectures of Planetary Systems (includes mass & orbit determination)
    - Characterizing Exoplanets
    - Solar System Observations with HWO
- 

# COPAG WGs of Interest

## *Uncovering the Drivers of Galaxy Growth*

**Description:** Study how galaxies, constituents, and their environments evolve over the history of the HWO-observable universe.

### **Sub-Groups:**

- *The intergalactic and circumgalactic medium:* Exploring the IGM and CGM in emission and (primarily) in absorption, with an emphasis on the UV
- *AGN over cosmic time:* Studying the central engines of galaxies and their impacts on galaxy evolution in imaging and spectroscopy as at multiple scales
- *Ionizing photons and their history:* Understanding the galaxies and their stars that drove reionization by observing their analogues at lower redshift in the UVOIR
- *The dark sector:* Exploring the nature of dark matter and dark energy via their impacts on galaxies and large scale structure

# COPAG WGs of Interest

## *Following the Evolution of the Elements Over Cosmic Time*

**Description:** Trace the rise of the periodic table via studies of the formation, distribution, and evolution of stars, and their deaths.

### **Sub-Groups:**

- *Star Formation:* UVOIR spectroscopy and imaging of star forming regions
- *Stars, stellar populations, and their environments:* UVOIR spectroscopy and imaging of stars from individuals in the Milky way, to populations in the Local Group, to stellar clusters across the universe
- *Transients:* Studies of supernovae, merger-driven stellar and stellar remnant explosions, and sources of gravitational wave events

# Getting Involved with HWO Working Groups

- See the HWO website for descriptions of each working group.
- Fill out the application form (link on HWO website).
- Contact the GIG (see slide 4) if you have any questions.
- Application Components:
  - Name
  - Institution (“self” is fine for those without formal affiliations)
  - Career Stage
  - Citizenship (required only for subgroups dealing with ITAR/EAR material)
  - Check boxes of groups you would like to join or co-chair
  - For potential co-chairs:
    - Blurb about interest and research background
    - Summary of leadership experience

NASA GOMAP Website



<https://science.nasa.gov/astrophysics/programs/habitable-worlds-observatory/>

# Working Group Charter

START has a WG charter that explains the basic structure of the WGs and their scope.

Available from the NASA HWO website, or find a GIG member

# What will the WGs do?

The START SG participants will begin with a definition of the key science cases, their objectives, and their observables to define the scientific figures of merit. These will be passed to the TAG for incorporation into modeling and analysis, and the process may iterate

TAG WG participants will develop codes & models to analyze various HWO architecture options, as well as track technology needs and develop roadmaps for technology maturation.

# Where we are at

- First Face-to-Face meeting in October/November, 2023
- Second Face-to-Face meeting planned for March, 2024
- Bi-weekly START/TAG telecons
- Additional telecons for START or TAG only
- Many, many more telecons to come as WGs spin up



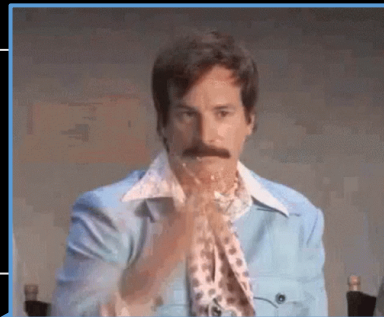


## MILESTONES

GOMAP  
Established

START &  
TAG Formed

Initial Working  
Groups  
Formed



Concept  
Maturity  
Level 3

Status  
Review

**WE ARE  
HERE**

## ACTIVITIES

*Begin Decadal Survey implementation*

*Investigate potential science cases & identify mission drivers*

*Solicit & select initial START & TAG members*

*Develop analytic science & engineering codes & models*

*Develop precursor science & technology calls*

*Assess technology gaps & aerospace landscape*

*Communicate GOMAP approach with HWO*

*Develop technology maturation roadmaps*

**Planning [2023 ✓]**

**Implementation [2024]**

## NASA Astrophysics Division Statement of Principles



*All participants in GOMAP-HWO activities must adhere to the APD Statement of Principles*

## American Astronomical Society (AAS) Code of Ethics



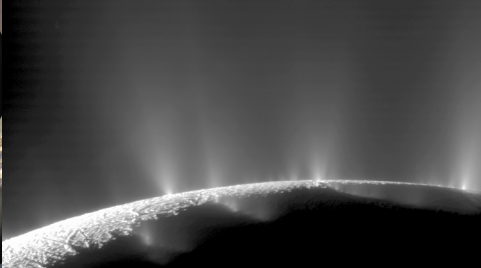
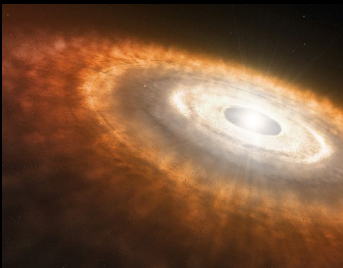
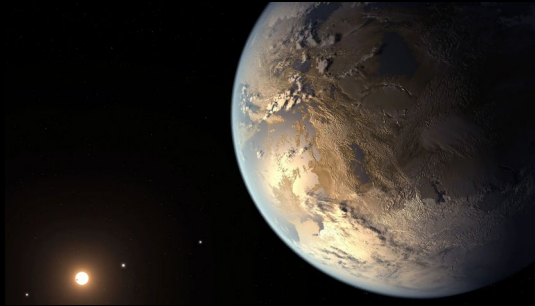
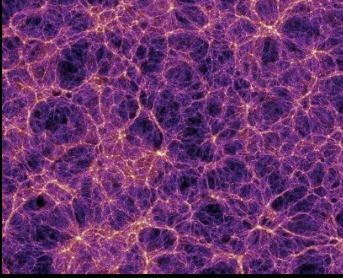
*The AAS Code of Ethics is required to be followed under the APD Statement of Principles*

## Reporting Protocol

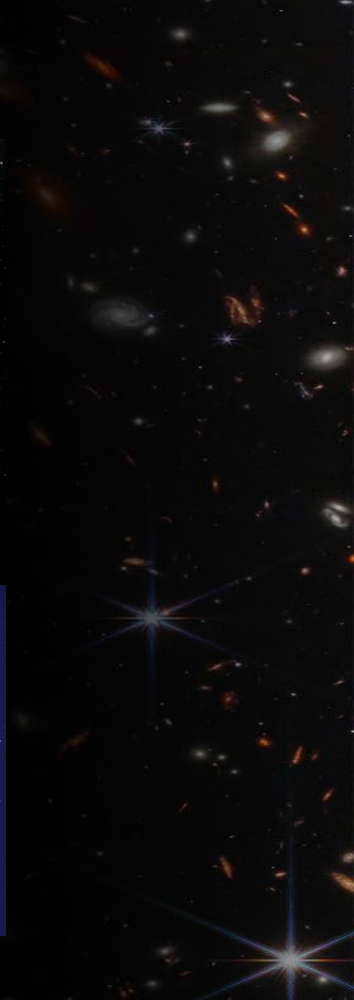
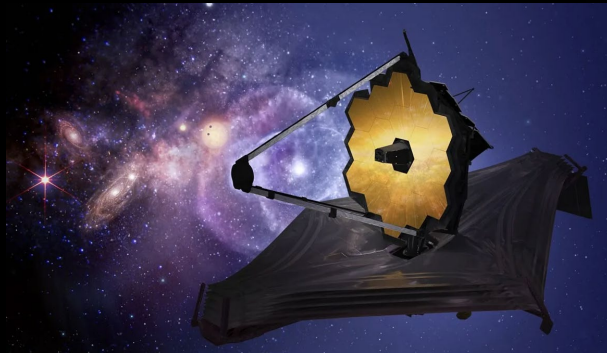
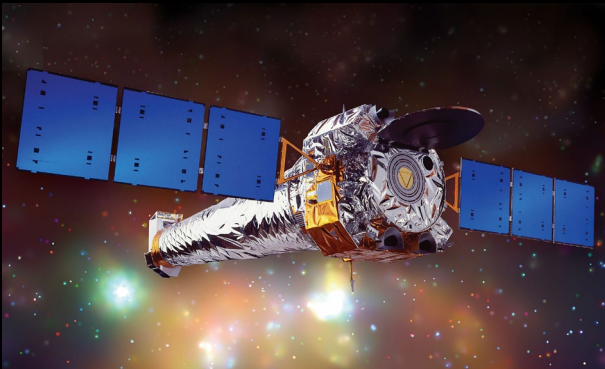
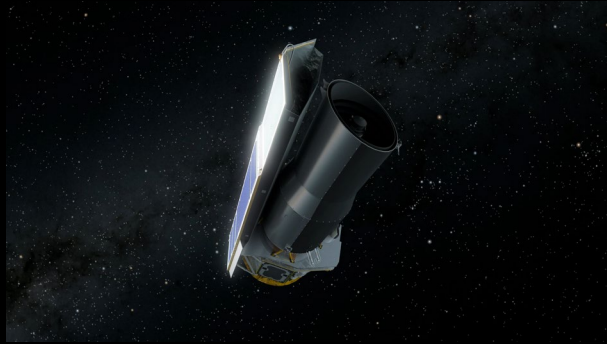
*Follow the procedures in the APD Statement of Principles and contact the HWO GIG*

*Use institutional reporting channels, as appropriate*

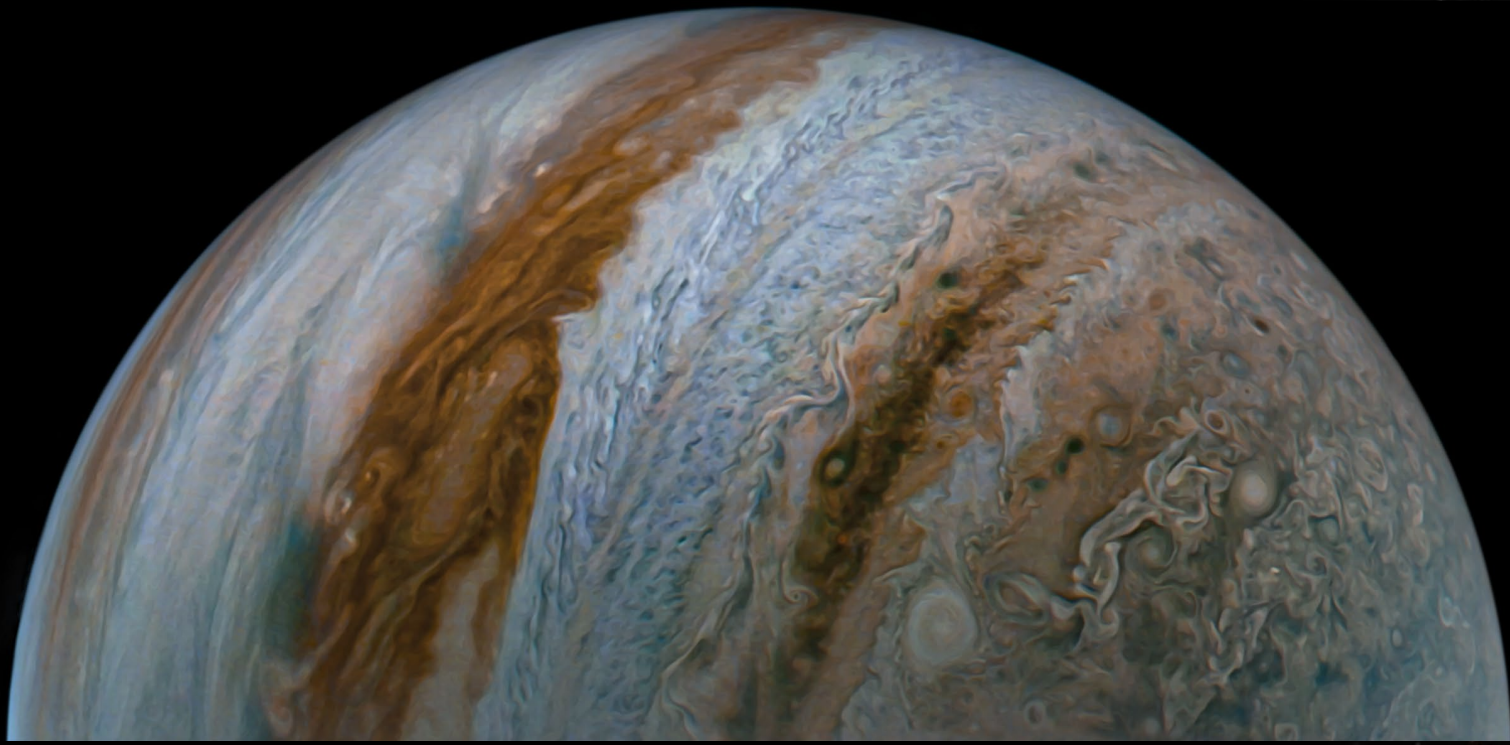
*NASA-funded individuals have access to NASA programs (Ombuds, Anti-Harassment, ODEO) and a facilitator to help navigate the various options*

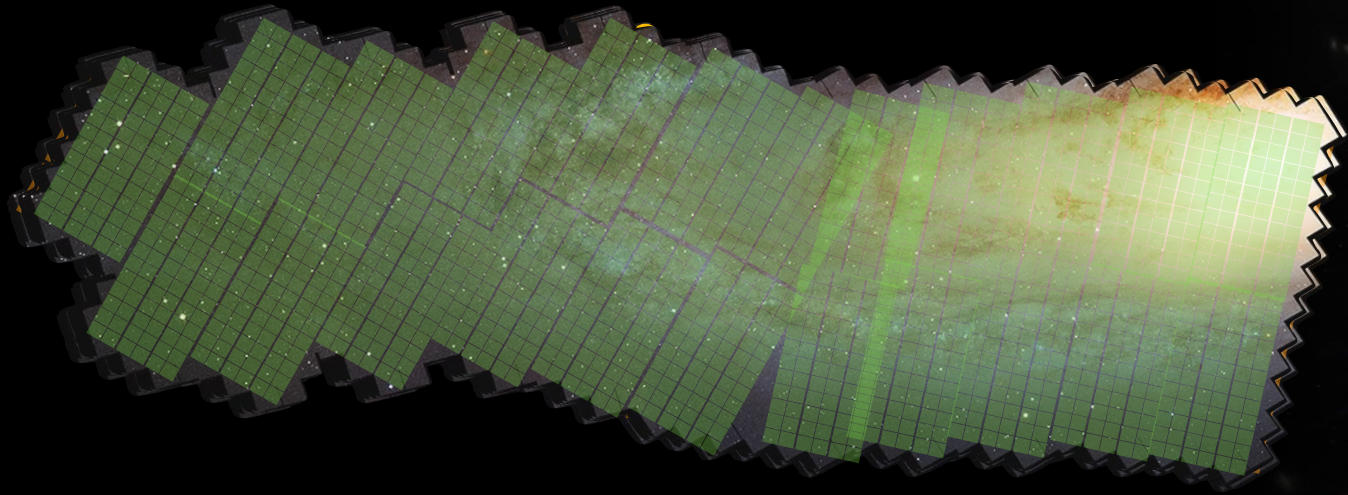


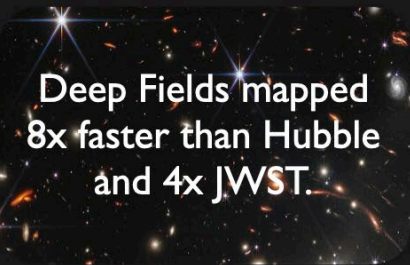
# The great observatories







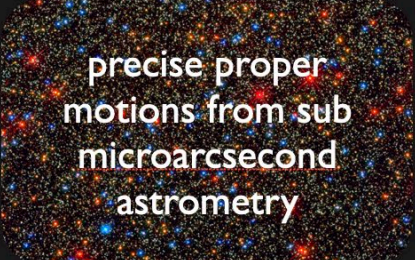





Deep Fields mapped  
8x faster than Hubble  
and 4x JWST.



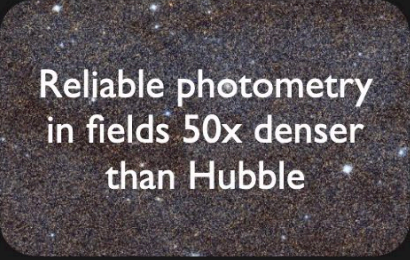
1.4 million individual  
shutters for intensive  
UV spectroscopy



precise proper  
motions from sub  
microarcsecond  
astrometry



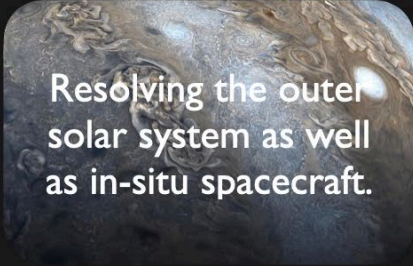
Mapping the baryon  
cycle in emission and  
absorption.



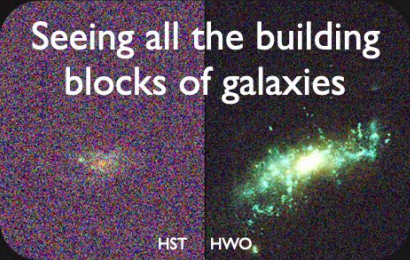
Reliable photometry  
in fields 50x denser  
than Hubble

H A B I T A B L E  
W O R L D S  
O B S E R V A T O R Y

Transformative Astrophysics Capabilities

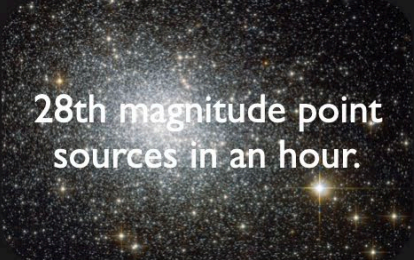


Resolving the outer  
solar system as well  
as in-situ spacecraft.



Seeing all the building  
blocks of galaxies

HST HWO



28th magnitude point  
sources in an hour.

Your idea here.



Servicing to achieve  
leaps in instrument  
capabilities

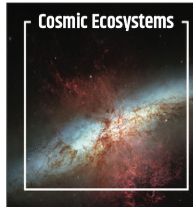
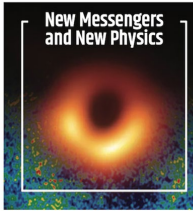
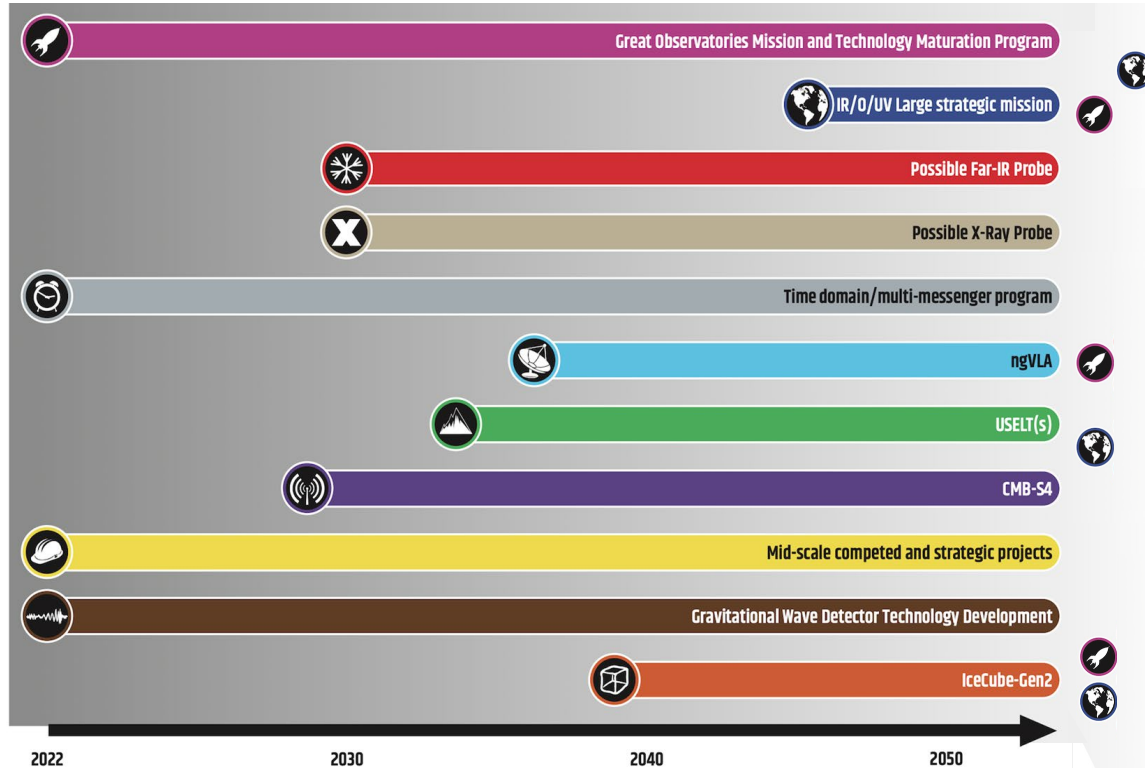


“The **same large aperture telescope that can identify Earth analogs** would be equally transformative for general astrophysics...”

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

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

“...will **directly address two-thirds of the 24 key science questions** identified in Chapter 2 and will contribute towards answering many of the others.”



## Astro2020's 3 Science Themes + Recommended Activities

## 12:45pm CT: GOMAP-HWO Background

*NASA HQ Update*

*The Story of Life in the Universe*

## 1:15pm CT: HWO Working Groups

*START & TAG Working Group Overview*

*Call for community-wide involvement*

Sign-up Here!



## 2:15pm CT: ROSES Precursor Science Program

*Lightning talks from ROSES-2022 selections*

*Submit to ROSES-2023 call*

## 2:41pm CT: HWO Technology

*Roadmap Team Reports*

*Industry Studies*



Mandatory NOI due 3/29

Full proposals due 4/26

Contact Doris Daou

Doris.Daou@nasa.gov

## Zoom Link

<https://berkeley.zoom.us/j/98889522047?pwd=Y29aaXBoWVZrWjVVOdnJaVFJDdFRWQT09>

Meeting ID: 988 8952 2047

Passcode: HWOaas

# HWO at AAS

Joint PAG 1/7 3pm

HWO at NASA booth, all meeting

NASA Townhall 1/8 12:45pm

Stellar Spectra for modeling exoplanetary atmospheres 1/8 6pm

NN-EXPLORE EPRV Initiative 1/9 9am

Science Drivers for UV in the gap years 1/9 9am, 1/9 1:30pm

**HWO Splinter 1/10 12:30pm**

Yield modeling tools 1/11 9am