The Habitable Worlds Observatory:

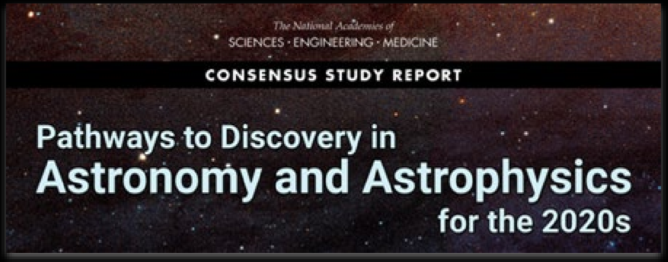
Updates & Opportunities for Community Involvement

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)

PhysCOS
New Orleans, LA
January 7, 2024

Habitable Worlds Observatory (HWO)

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

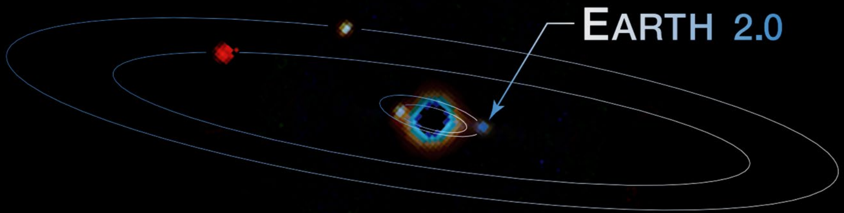

The National Academies of SCIENCES · ENGINEERING · MEDICINE

CONSENSUS STUDY REPORT

Pathways to Discovery in Astronomy and Astrophysics for the 2020s

Large IR/Opt/UV observatory performing transformative astrophysics

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



Slide by Megan Ansdell (GOMAP PS)

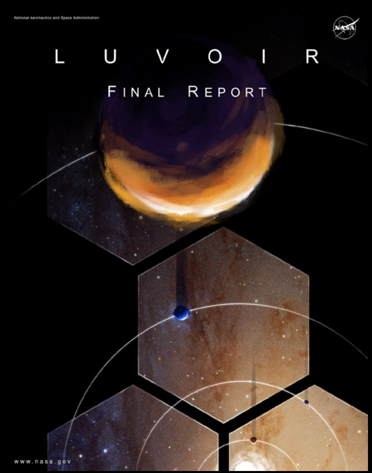
Great Observatory Maturation Program (GOMAP)

Independent Research Papers

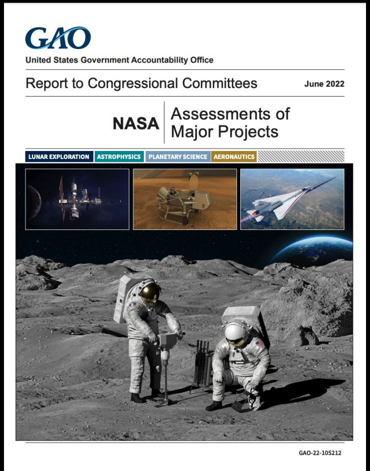
Challenges and Potential Solutions to Develop and Fund NASA Flagship Missions

Robert E. Bitten, The Aerospace Corporation, 2310 E. El Segundo Blvd., El Segundo, CA 90245, 310-336-1917, robert.e.bitten@aero.org
Stephen A. Shinn, NASA Goddard Space Flight Center, 8800 Greenbelt Road, Greenbelt, Maryland 20771, 301-286-5894, stephen.a.shinn@nasa.gov
Debra L. Emmons, The Aerospace Corporation, 2310 E. El Segundo Blvd., El Segundo, CA 90245, 310-418-7892, debra.l.emmons@aero.org

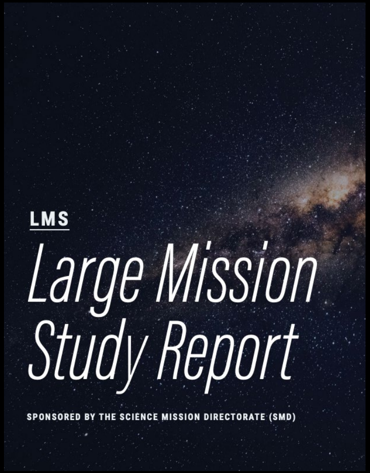
Mission Concept Reports



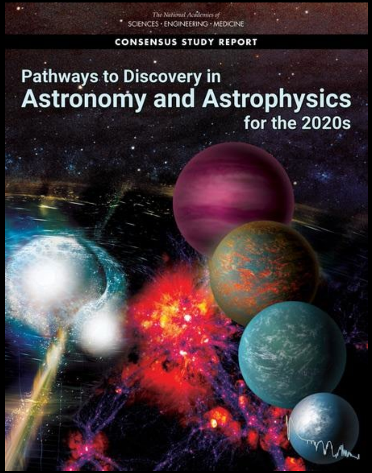
GAO Report on Major Projects



NASA SMD Internal Studies



National Academy Reports



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**]

Slide by Megan Ansdell (GOMAP PS)

GOMAP Integration Team (GIG)

NASA HQ Leadership

Program Executive	Program Scientist	Deputy Program Scientist
		
Julie Crooke	*Megan Ansdell*	*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

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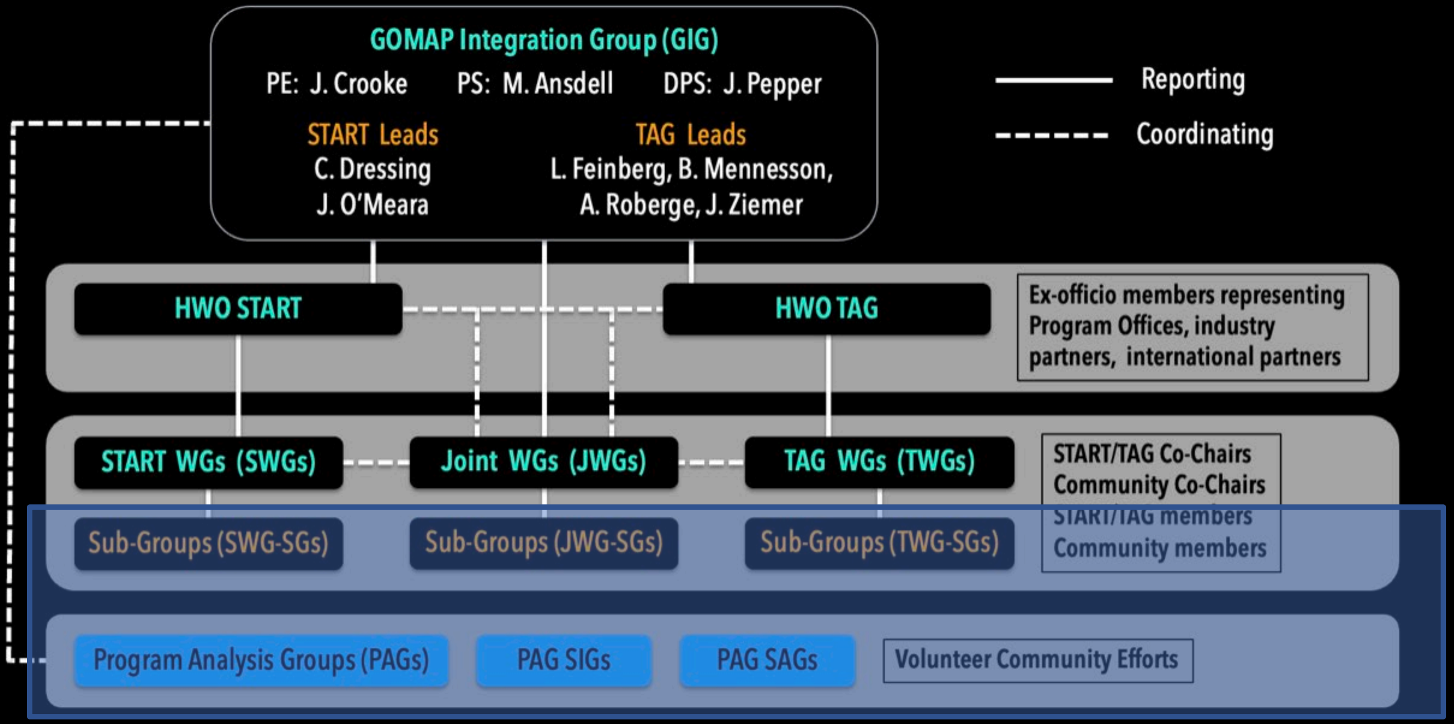
Overall Structure



YOU!

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-Contras 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

PhysCOS 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:

- *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

PhysCOS 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:

- *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/

What will the WGs do?

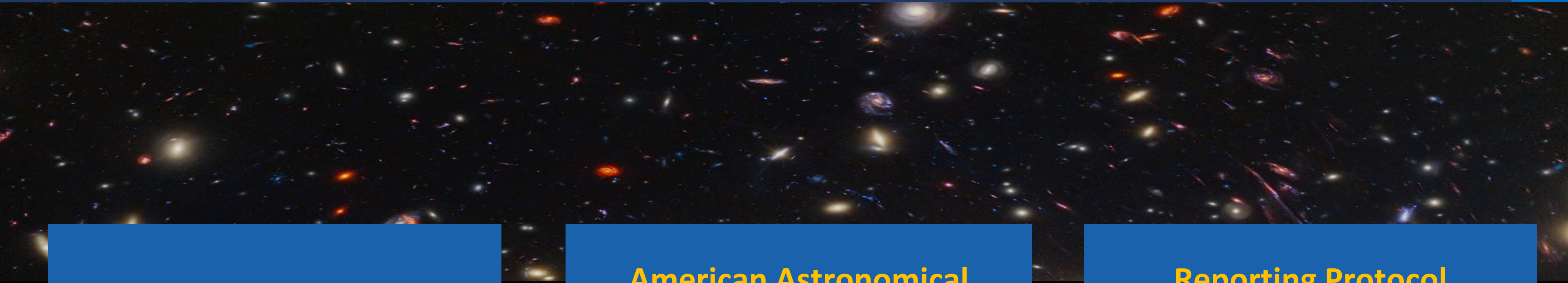
The START SG participants will begin with a definition of the key science cases, their objectives, and their observables to define the scientific figures of merit. These will be passed to the TAG for incorporation into modeling and analysis, and the process may iterate

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

GOMAP-HWO Code of Conduct & Reporting Protocol



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

Slide by Megan Ansdell (GOMAP PS)

Transformative Astrophysics with HWO

Courtesy Jason Tumlinson, STScI

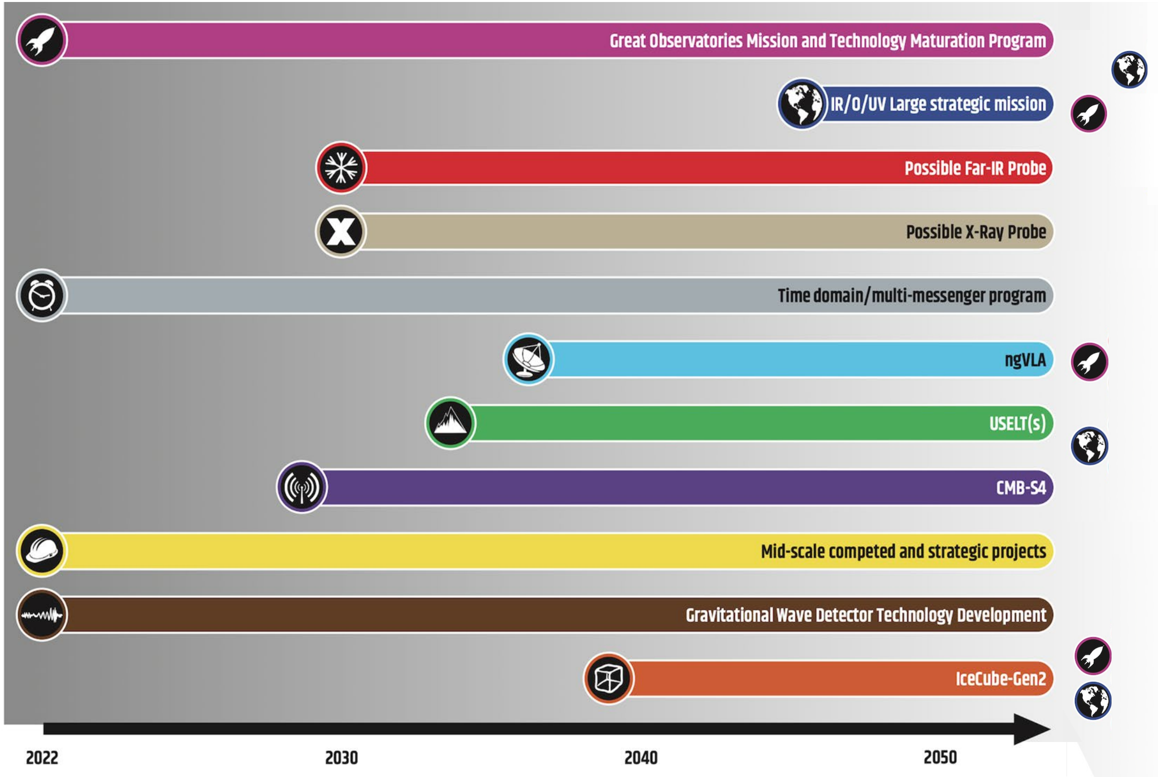
Transformative Astrophysics with HWO

"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

Slide by Megan Ansdell (GOMAP PS)

HWO Splinter Session on Wednesday, January 10 in R08/R09 and on Zoom

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!

Mandatory NOI due 3/29
Full proposals due 4/26

Contact Doris Daou
Doris.Daou@nasa.gov

2:41pm CT: HWO Technology

Roadmap Team Reports
Industry Studies

Zoom Link

https://berkeley.zoom.us/j/98889522047?pwd=Y29aaXBoWVZrWjVOdnJaVFJDdFRWQT09
Meeting ID: 988 8952 2047
Passcode: HWOaas

Adapted from slide by Megan Ansdell (GOMAP PS)

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