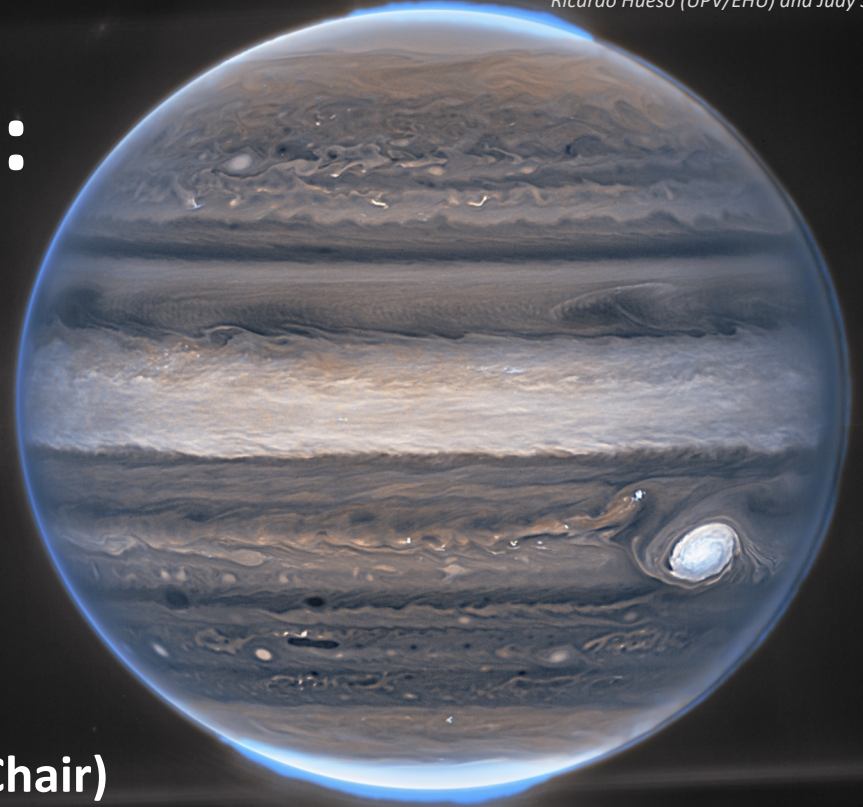


The Habitable Worlds Observatory: Updates & Opportunities for Community Involvement

JWST NIRCам image of Jupiter
Credit: NASA, ESA, CSA, Jupiter ERS Team; image processing by
Ricardo Hueso (UPV/EHU) and Judy Schmidt.

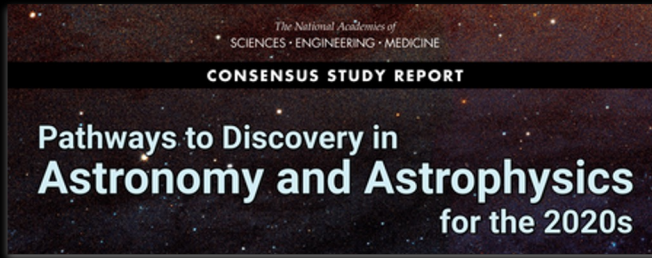


Courtney Dressing (she/her; START Co-Chair)

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

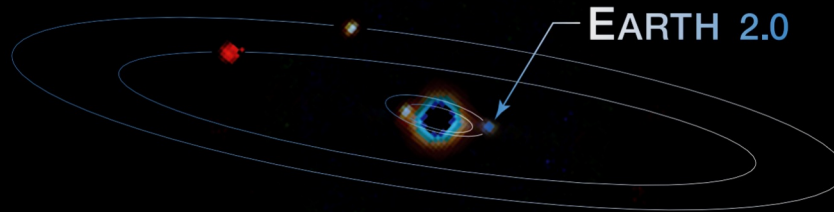
ExoPAG 29
New Orleans, LA
January 7, 2024

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



Great Observatory Maturation Program (GOMAP)

Independent Research Papers

Mission Concept Reports

GAO Report on Major Projects

NASA SMD Internal Studies

National Academy Reports

Challenges and Potential Solutions to Develop and Fund NASA Flagship Missions

Robert E. Bilim, The Aerospace Corporation
 Stephen A. Bilim, NASA Goddard Space Flight Center
 Delia L. Farnsworth, The Aerospace Corporation

Abstract—Large, strategic “Flagship” missions have become increasingly important to the national security and space exploration efforts of the United States. However, the development of such missions is a complex and costly process. This paper identifies the challenges and potential solutions to develop and fund NASA Flagship missions. The paper discusses the importance of these missions and the challenges associated with their development and funding. It also provides potential solutions to these challenges, including the use of public-private partnerships, the development of new funding mechanisms, and the use of innovative technologies.

TABLE OF CONTENTS

1. DEFINITION OF FLAGSHIP MISSIONS
2. BENEFITS OF FLAGSHIP MISSIONS
3. DIFFICULTY OF ESTABLISHING FLAGSHIP MISSIONS
4. FLAGSHIP COST GROWTH
5. COSTS CAN BE REDUCED
6. A POTENTIAL NEW APPROACH
7. SUMMARY
8. ACKNOWLEDGMENTS
9. REFERENCES
10. BIOGRAPHY

1. DEFINITION OF FLAGSHIP MISSIONS
 According to Michael-Thomas’ Dictionary, a Flagship is: (1) the ship that carries the commander of a fleet or (2) a mission that is the most important or significant of a group of missions. This paper defines a Flagship mission as a large-scale, high-cost, high-risk mission that is the most important or significant of a group of missions. It is a mission that is the most important or significant of a group of missions. It is a mission that is the most important or significant of a group of missions.



GAO Report to Congressional Committees: NASA Assessments of Major Projects

United States Government Accountability Office
 Report to Congressional Committees
 June 2002

NASA Assessments of Major Projects

LUNAR EXPLORATION | **ASTROPHYSICS** | **PLANETARY SCIENCE** | **AERONAUTICS**

GAO-02-300312

LMS Large Mission Study Report

SPONSORED BY THE SCIENCE MISSION DIRECTORATE (SMD)

Pathways to Discovery in Astronomy and Astrophysics for the 2020s

THE NATIONAL ACADEMIES OF SCIENCES, ENGINEERING, & MEDICINE
 CONSENSUS STUDY REPORT

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**]

NASA HQ Leadership

Program Executive



Julie Crooke

Program Scientist



Megan Ansdell

Deputy Program Scientist



Joshua 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 Menesson
JPL



Aki Roberge
GSFC



John Ziemer
JPL

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.

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]

TAG Working Groups

- **Science-Engineering Interface** (co-chairs Patrick Morrissey & Breann Sitarski)
- **Systems** (co-chairs Michael Menzel & Stuart Shaklan)
 - 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; co-chairs Matthew Bolcar & Feng Zhao)
 - Sensing & Control
 - Mirrors
 - Coronagraphs
 - Detectors
 - Artificial Intelligence/Machine Learning
- **Servicing** (co-chairs Julie Van Campen & John Grunsfeld)

Ask the TAG co-chairs for more details about TAG working groups including open leadership positions.

Science & Engineering Joint Working Groups

- **Comparison of Past Studies** (chair Scott Gaudi)
- **Science Case Simulation** (co-chairs Natasha Batalha & Rachel Osten)
 - Exoplanet Direct Imaging Yields
 - Galaxy Evolution in the UV
 - Astrometry
- **Science Data Simulation** (co-chairs Tom Greene & Jason Tumlinson)
 - High-Contrast
 - UV
 - Wide-field Imaging
- **Astronomy in the 2030s/2040s** (co-chairs TBD)
 - Space-based
 - Ground-based
- **Artificial Intelligence & Machine Learning** (co-chairs Megan Ansdell & TBD)
- **GOMAP Synergies for Future Missions** (co-chairs Jessica Gaskin & Jim Oschmann)

Joint Working Groups

- **Diversity, Equity, Inclusion, & Accessibility** (co-chairs Evan Scannapieco & TBD)
- **Mentorship** (co-chairs TBD)
 - *The mentorship working group will initially be part of the DEIA working group.*
- **Communications** (co-chairs Travis Schirner & Amber Straughn)

START Working Groups

- **Evolution of the Elements** (co-chairs Janice Lee & TBD)
 - Stars, Stellar Populations, & Their Environments
 - Star Formation
 - Transients
- **Galaxy Growth** (co-chairs Swara Ravindranath & TBD)
 - The Dark Sector
 - AGN Over Cosmic Time
 - Intergalactic & Circumgalactic Medium
 - Ionizing Photons and Their History
- **Living Worlds** (co-chairs Giada Arney & Niki Paranteau)
 - Biosignature Possibilities
 - Biosignature Interpretation
 - Target Stars and Systems
- **Solar Systems in Context** (co-chairs Ty Robinson & Evgenya Shkolnik)
 - Birth and Evolution of Planetary Systems
 - Demographics & Architectures of Planetary Systems (includes mass & orbit determination)
 - Characterizing Exoplanets (habitable and non-habitable)
 - Solar System Observations with HWO

Living Worlds Working Group

Explore finding & characterizing potentially habitable exoplanets and searching them for the possibility of life with HWO.

- **Biosignature Possibilities:** consider the wide variety of biosignatures (e.g., biogenic gases, aerosols, surface biosignatures, technosignatures) that could be detectable with HWO, the conditions under which they might occur, and the associated measurement requirements.
- **Biosignature Interpretation:** explore how potential biosignatures could be assessed and consider the additional information about the planet and planetary system required to interpret biosignatures and rule out false positives.
- **Target Stars and Systems:** build on previous work to assemble current knowledge of likely HWO target stars, identify knowledge gaps, and consider the ability of precursor observations, contemporaneous observations with other facilities, and HWO observations to constrain important properties of host stars and their planetary systems.

Solar Systems in Context Working Group

Explore UVOIR imaging and spectroscopy of Solar System objects at all scales, along with exoplanet observations to understand the full range of planet possibilities and histories.

- **Birth and Evolution of Planetary Systems:** consider the observational capabilities required to advance understanding of the formation of planetary systems during embedded, protoplanetary, and debris disk stages.
- **Demographics & Architectures of Planetary Systems:** synthesize current knowledge of exoplanet occurrence rates and system architectures for the types of stars that HWO will target and assess the sensitivity and accessibility required to constrain system architectures.
- **Characterizing Exoplanets:** address observations and characterization of exoplanets that are observed by HWO directly or indirectly (i.e., phase curve, transits, eclipses).
- **Solar System Observations with HWO:** consider remote sensing, often at high cadence, of solar system planets, their moons, and small bodies using high spatial resolution imaging and UVOIR spectroscopy.

Getting Involved with HWO Working Groups

- ***Everyone is welcome and encouraged to join 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 (**early career researchers are encouraged to apply!**)
 - 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/>

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

Please Apply to Co-Chair Planetary Subgroups And Help Advertise These Positions

- **Solar Systems in Context** (co-chairs Ty Robinson & Evgenya Shkolnik)
 - **Characterizing Exoplanets Co-Chair** (with Renyu Hu)
 - **Solar System Observations Co-Chair** (with Lynnae Quick)
 - **Demographics & Architectures of Planetary Systems Co-Chair** (with Jessie Christiansen)
 - **Birth & Evolution of Planetary Systems Co-Chairs** (2 people needed)
- **Living Worlds** (co-chairs Giada Arney & Niki Paranteau)
 - **Biosignature Possibilities Co-Chairs** (2 people needed)
 - **Biosignature Interpretation Co-Chairs** (2 people needed)
 - **Target Stars and Systems Co-Chair** (with Eric Mamajek)

Please Help Advertise Openings for Co-Chairs of Non-Planetary Working Groups and Subgroups

- **Evolution of the Elements Co-Chair** (with Janice Lee)
 - **Star Formation Co-Chairs** (2 people needed)
 - **Stars, Stellar Populations, and their Environments Co-Chairs** (2 people needed)
 - **Transients Co-Chair** (with Eric Burns)
- **Galaxy Growth Co-Chair** (with Swara Ravindranath)
 - **The Intergalactic & Circumgalactic Medium Co-Chairs** (2 people needed)
 - **AGN Over Cosmic Time Co-Chairs** (2 people needed)
 - **Ionizing Photons and Their History Co-Chairs** (2 people needed)
 - **The Dark Sector Co-Chair** (with Jason Rhodes)

Please Apply to Co-Chair Joint Working Groups

- **Diversity, Equity, Inclusion, & Accessibility (DEIA) and Mentorship Co-Chairs** (with Evan Scannapieco)
 - *This working group will split into a DEIA working group and a mentorship working group once the mentorship program is launched, so we're looking for **three additional co-chairs**.*
- **Artificial Intelligence/Machine Learning Co-Chair** (with Megan Ansdell)
- **Ground-Based Astronomy in the 2030s/2040s Co-Chairs** (2 people needed)
- **Space-Based Astronomy in the 2030s/2040s Co-Chairs** (2 people needed)

(Selected) Progress So Far

- Held multiple virtual meetings
- **Met in person** in Washington, D.C. in October 2023
- TAG conducted a 2-day virtual meeting in December 2023
- Selected initial set of exploratory analytic cases
- **Established working group structure**
- Determined initial goals and deliverables for working groups
- **Issued a call for community leadership and participation** in working groups and subgroups
- Began working on HWO mentorship program and met with representatives from the NASA Bridge Program
- **Set up a new website!**

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

What's Next For the START & TAG?

- **We're soliciting applications for participation in working groups. Please apply and help advertise the positions!**
 - **Co-chair applications will be reviewed starting January 26.**
 - **Expressions of interest in membership can be submitted at any time.**
 - Membership is open to all (except for groups dealing ITAR/EAR material)
 - Participants must abide by the APD Statement of Principles.
- We're planning our second in-person START & TAG meeting
 - March 11-13 in Pasadena, CA
 - The draft agenda and instructions for remote participation will be distributed after AAS.
- We'll continue to have regular START and TAG virtual meetings.
- Working groups and subgroups will work towards their goals.

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=Y29aaXBoWVZrWjVOdnJaVFJDdFRWQT09>

Meeting ID: 988 8952 2047

Passcode: HWOaas

Additional HWO Events at AAS

Based on list curated by Janice Lee at <https://docs.google.com/spreadsheets/d/1M8FqEQaBo-KIkCj3g2oAuRIqKs89agRmVvLD-x2OoRE/edit#gid=992142808>

Day	Time (CT)	Event	Location
Sunday	9am - 12:30pm	<u>ExoPAG</u>	Quarterdeck Ballroom
	9am - 1pm	COPAG	244/245
	3pm - 5pm	Joint PAG	244/245
All Week	Exhibit Hall Hours	HWO Table at NASA Booth	Exhibit Hall
Monday	12:45pm - 1:45pm	NASA Town Hall	Great Hall A
	6pm - 8pm	X-ray, UV, optical, IR stellar spectra for modeling and integrating exoplanetary atmospheres from JWST to HWO	242
Tuesday	9am - 11am	NN-Explore EPRV Initiative	R08/09
	9am - 11:30am 1:30pm - 3:30pm	Mind the Gap - Science Drivers for UV Spectroscopy Missions in the Gap Years (NASA UV STIG)	R07
Wednesday	12:45pm - 3:30pm	HWO Splinter Session (<i>Can Join Remotely via Zoom</i>)	R08/09
Thursday	9am - 11am	Yield Modeling Tools for Direct Imaging of Exoplanets Remix	219

Join the HWO-News Mailing List

1. Send an email to hwo-news-join@lists.nasa.gov
2. The subject and body of the message can be left blank.
3. Check your inbox (and spam folder) for an email requesting you to confirm your email address.
4. Follow the instructions in the email to confirm your email address.

If you decide to leave the list, you may unsubscribe by emailing hwo-news-leave@lists.nasa.gov and following steps 2-4 above

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