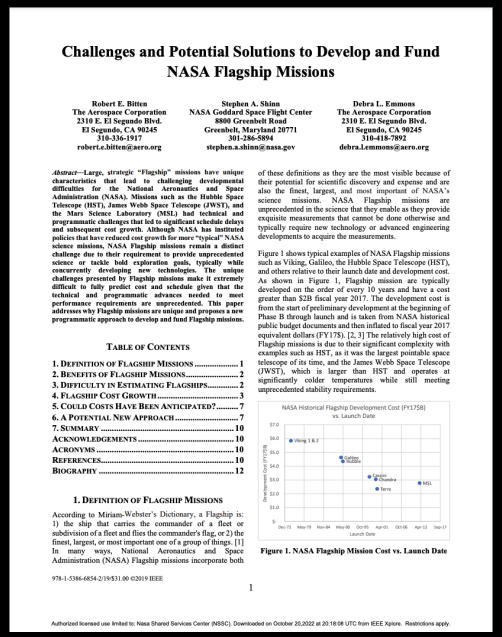
# How to get involved in Habitable Worlds Observatory

Eric Burns

# 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

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*Abstract*—Large, strategic "Flagship" missions have unique characteristics that lead to challenging developmental difficulties for the National Aeronautics and Space Administration (NASA). Missions such as the Hubble Space Telescope (HST), James Webb Space Telescope (JWST), and the Mars Science Laboratory (MSL) had technical and programmatic challenges that led to significant schedule delays and subsequent cost growth. Although NASA has instituted policies that have reduced cost growth for more "typical" NASA science missions, NASA Flagship missions remain a distinct challenge due to their requirement to provide unprecedented science or tackle bold exploration goals, typically while concurrently developing new technologies. The unique challenges presented by Flagship missions make it extremely difficult to fully predict cost and schedule given that the technical and programmatic advances needed to meet performance requirements are unprecedented. This paper addresses why Flagship missions are unique and proposes a new programmatic approach to develop and fund Flagship missions.

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1. DEFINITION OF FLAGSHIP MISSIONS

According to Miriam-Webster's Dictionary, a Flagship is: 1) the ship that carries the commander of a fleet or subdivision of a fleet and flies the commander's flag, or 2) the finest, largest, or most important one of a group of things. [1] In many ways, National Aeronautics and Space Administration (NASA) Flagship missions incorporate both of these definitions as they are the most visible because of their potential for scientific discovery and expense and are also the finest, largest, and most important of NASA's science missions. NASA Flagship missions are unprecedented in the science that they enable as they provide exquisite measurements that cannot be done otherwise and typically require new technology or advanced engineering developments to acquire the measurements.

Figure 1 shows typical examples of NASA Flagship missions such as Viking, Galileo, the Hubble Space Telescope (HST), and others relative to their launch date and development cost. As shown in Figure 1, Flagship mission are typically developed on the order of every 10 years and have a cost greater than $2B fiscal year 2017. The development cost is from the start of preliminary development at the beginning of Phase B through launch and is taken from NASA historical public budget documents and then inflated to fiscal year 2017 equivalent dollars (FY17$). [2, 3] The relatively high cost of Flagship missions is due to their significant complexity with examples such as HST, as it was the largest pointable space telescope of its time, and the James Webb Space Telescope (JWST), which is larger than HST and operates at significantly colder temperatures while still meeting unprecedented stability requirements.




Figure 1. NASA Flagship Mission Cost vs. Launch Date

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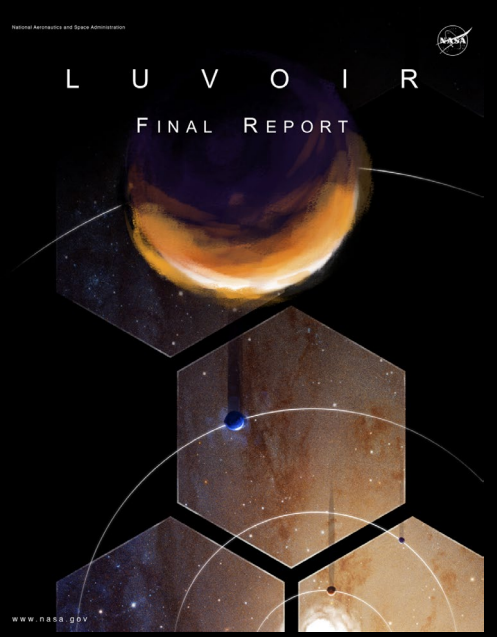
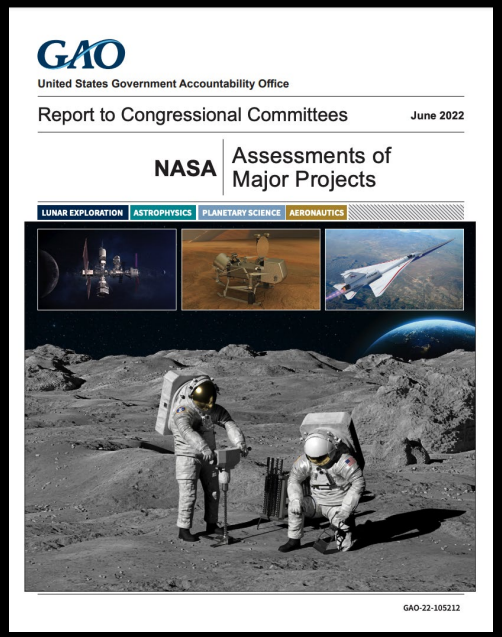
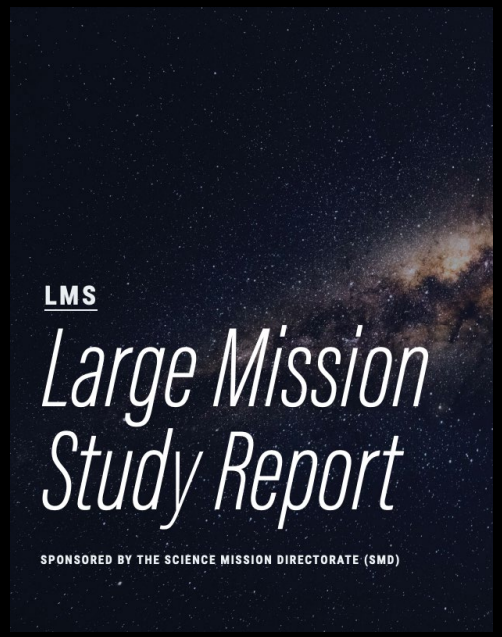
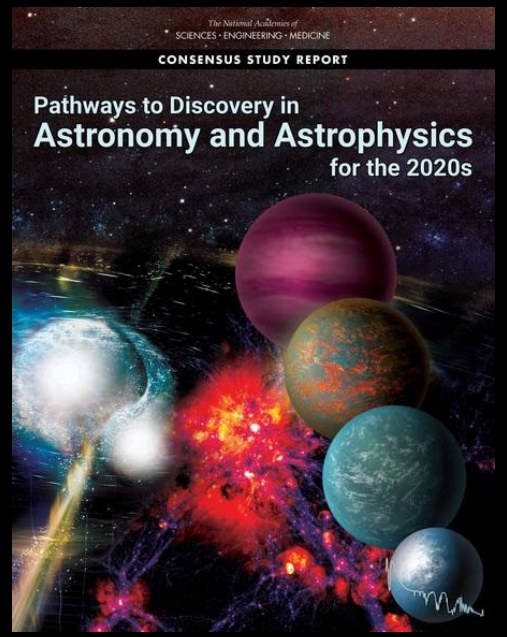



Finding: For a decadal survey to confidently recommend implementation of a strategic mission as its highest priority, the mission's technology and architecture need to be **developed to a level of maturity that allows a reasonable assessment of budget profile, scientific performance, and technology risk**. 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.**

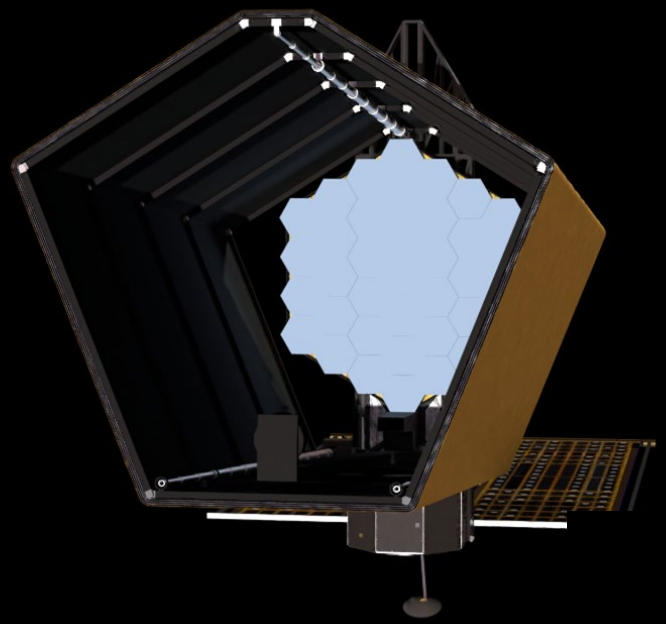
Recommendation:

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**]

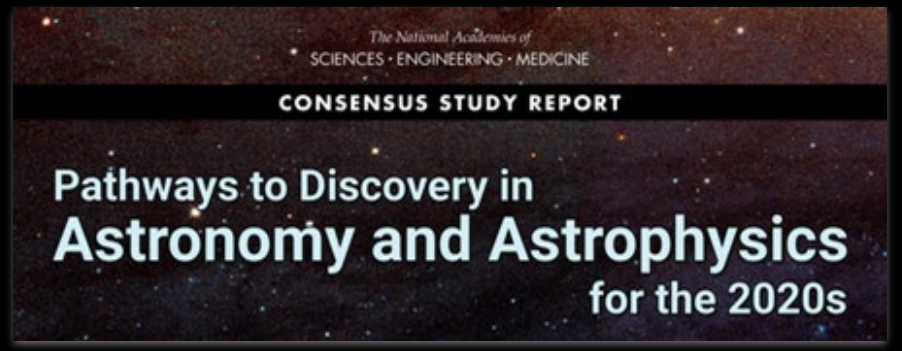
# *Habitable Worlds Observatory (HWO)*



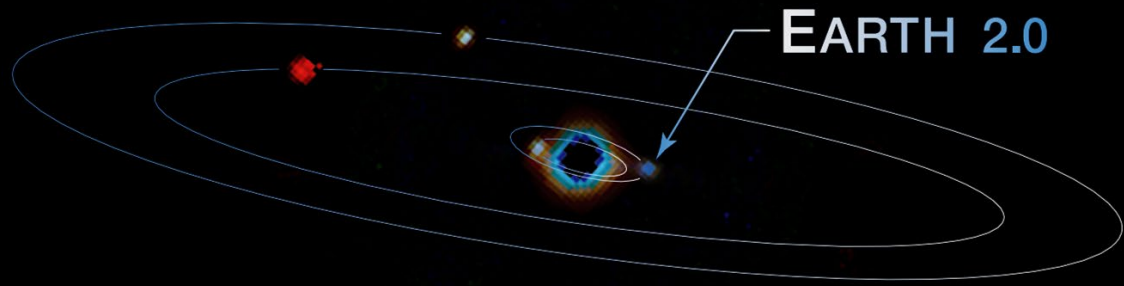
**NASA's next flagship mission concept recommended by Astro2020 Decadal Survey**



**Large-aperture IR/Opt/UV observatory performing transformative astrophysics**

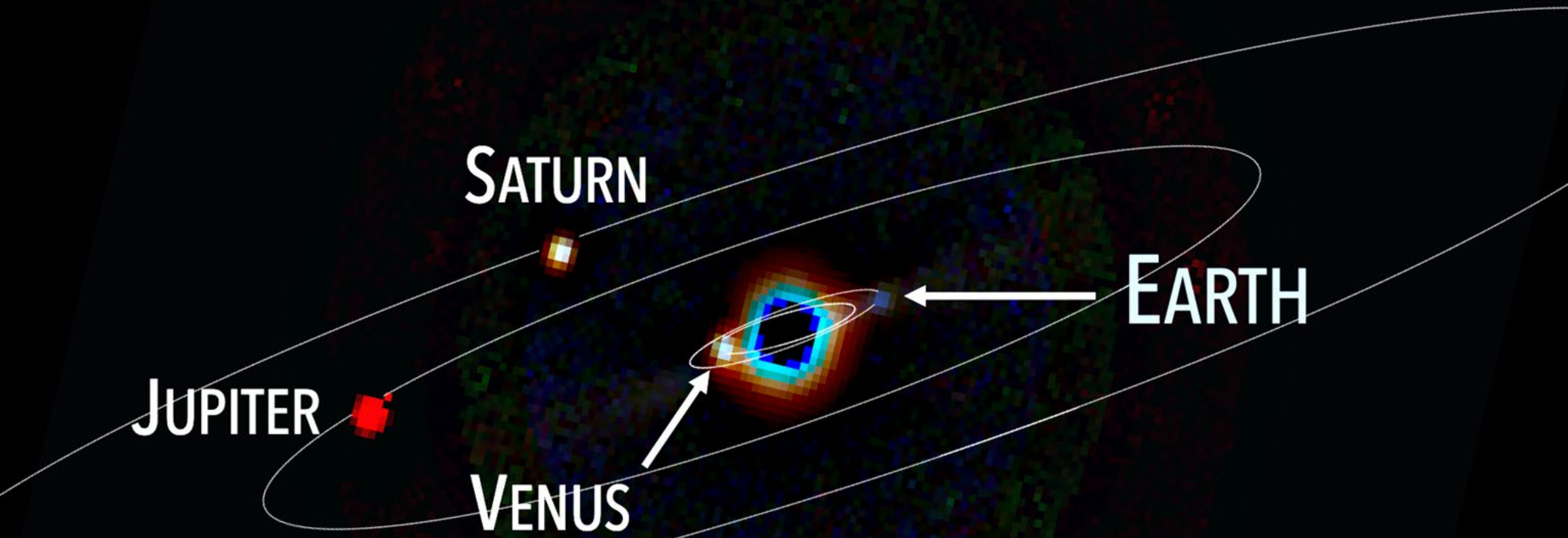



**First telescope designed specifically to search for signs of life on planets outside our solar system**



# Habitable Worlds Observatory Science

# ANOTHER EARTH




Preliminary simulated high-contrast image of the Solar System with a coronagraph on HWO

Credit: Kammerer, Pueyo (STScI), Juanola Parramon, Stark (GSFC)

“If planets like Earth are rare, our own world becomes even more precious.
If we do discover the signature of life in another planetary system, it will
change our place in the universe in a way not seen since the days of Copernicus.”

*National Academies of Sciences, Engineering, and Medicine Astro2020 Decadal Survey Report (Nov 2021)*

# Implementing HWO's GOMAP Phase



DEFINE MISSION-DRIVING **TRADE SPACES** & HOW TO EXPLORE THEM

## MILESTONES

- GOMAP Established
- START & TAG Formed
- Initial Working Groups Formed
- Concept Maturity Level 3
- Status Review

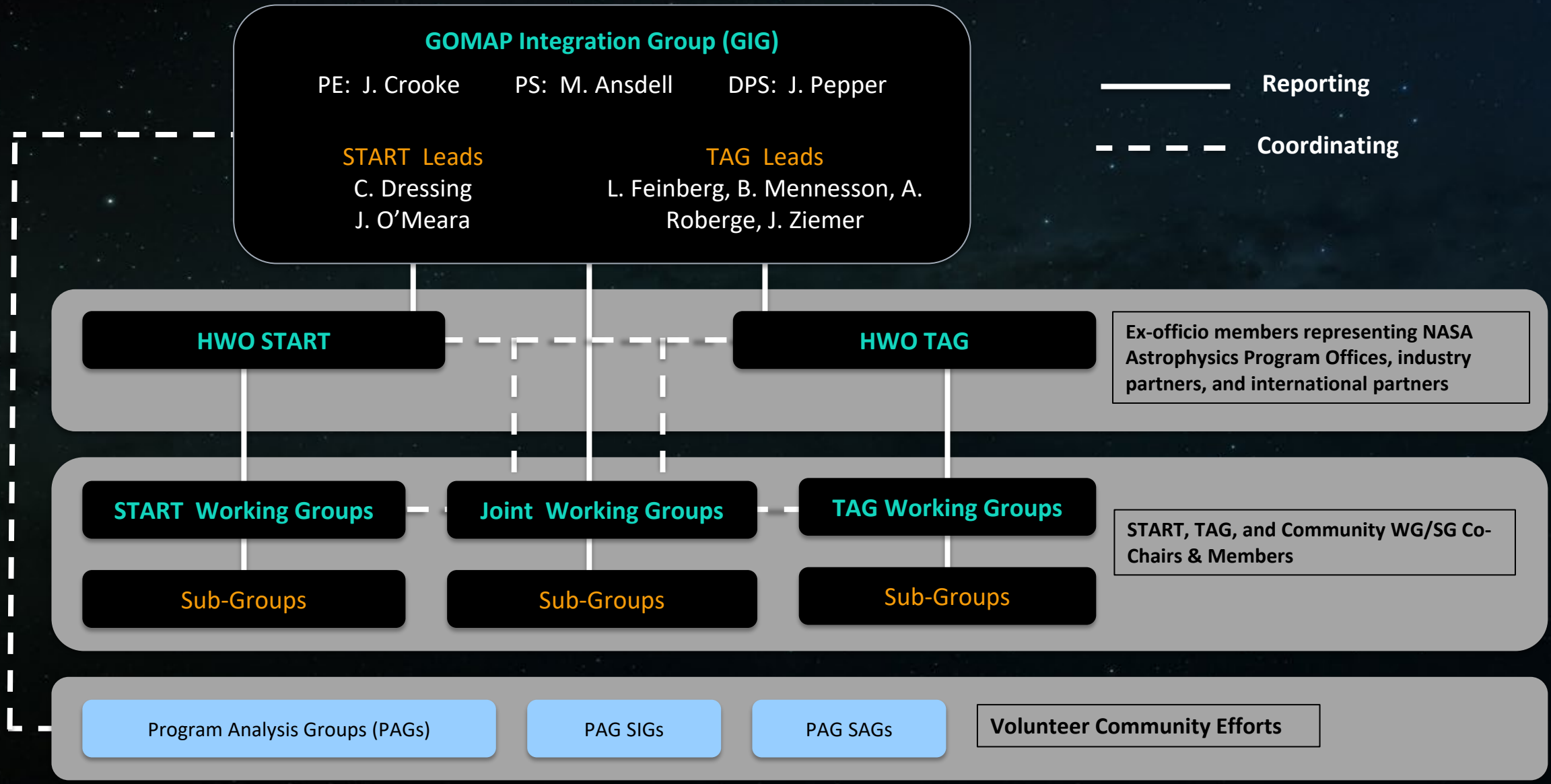
WE ARE HERE

## 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]*** →

# ORGANIZATION & RELATIONSHIPS



# HWO Working Groups

*Likely to evolve in future*

## START

- Galaxy Growth
  *Ravindranath & Postman*
- Evolution of the Elements
  *Lee & Scowen*
- Ground-Based Astronomy in the 2030s/2040s
  *Lopez-Morales & Miyazaki*
- Space-Based Astronomy in the 2030s/2040s
  *Petre & Kataria*
- Living Worlds
  *Arney & Parenteau*
- Solar System in Context
  *Robinson & Shkolnik*

## Joint & Community

- DEIA & Mentorship
  *Scannapieco & TBD*
- Science Case Simulation
  *Batalha & Osten*
- GOMAP Synergies for Future Missions
  *Gaskin & Oschmann*
- Science Data Simulation
  *Greene & Tumlinson*
- Communications
  *Schirner & Straughn*
- Science-Engineering Interface
  *Morrissey & Sitarski*
- Artificial Intelligence & Machine Learning
  *Ansdell & Dean*
- Past Studies Comparison
  *Gaudi*

## TAG

- Systems
  *Menzel & Shaklan*
- Integrated Modeling
  *Levine & Liu*
- Technology
  *Bolcar & Zhao*
- Servicing
  *Van Campen & Grunsfeld*

# START First Steps

| HWO Science Goals from Astro2020 | Goals to Objectives | Objectives to Measurements | Measurements to Observations |
|---|---|---|---|
| *High-level Questions* | *Define Investigations* | *Determine Physical Parameters to Measure* | *Define Needed Observations* |
| *"How did the seeds of Solar System planets first come together?"* | *"Discover trans-Neptunian objects down to sizes that distinguish between different planetesimal formation scenarios"* | *"Detection of 30 TNOs with diameters ~4km out to 40 AU to constrain the small end of the size distribution at X precision"* | *"Detection of R< 31.5 mag objects at SNR > 5 in a 0.017 deg$^2$ region imaged in R band"* |

**This work feeds the first four columns of a future Science Traceability Matrix (STM)**

**But what we really want is to …**

# START First Steps

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**Quantify science returns as functions of observatory capabilities.**

**Determine correlations & derivatives.**

**Start building an integrated science model that will connect to engineering models.**

**Dynamic Integrated Science Return Analysis (DISRA)**

# TAG First Steps: Exploratory Analytic Cases (EACs)

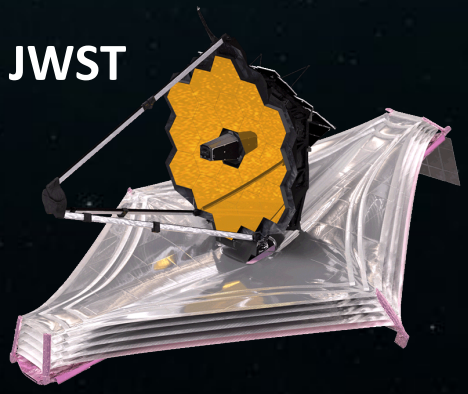
1st round mission architectures that will be used to explore the HWO trade space. Purposes …

- Practice end-to-end modeling, from science to engineering. Develop initial models & codes to ”pipeclean” the process using representative examples
- Use EACs to identify key technology gaps and guide maturation of potential technology solutions
- Provide feedback to rocket vendors as soon as possible to help influence their direction

**We don’t expect any of the cases studied will become a baseline design going forward.**
**These are only coarse models intended to explore and practice.**

**Early JWST**

**Final JWST**



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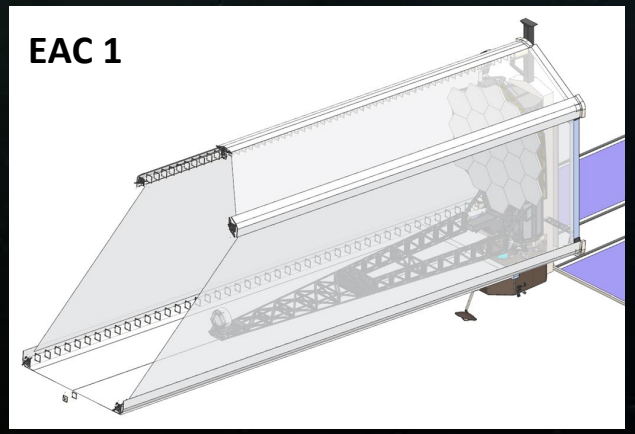
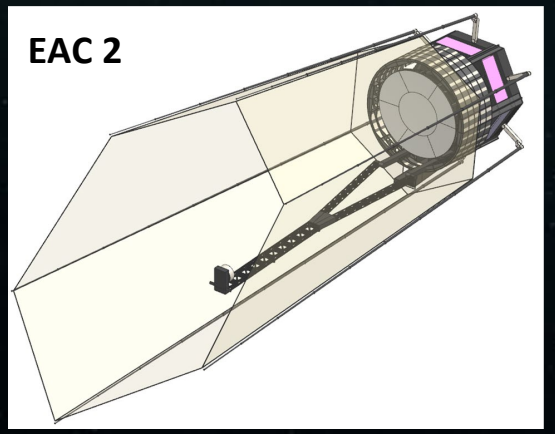
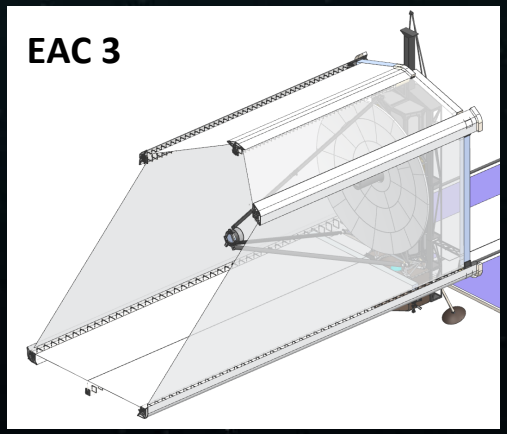
**Exploration of three 1st round EACs will take ~ 1 year. Findings will fold into 2nd round of EACs.**




**6-m inner diameter / 7.2-m outer diameter off-axis**




**6-m diameter off-axis**




**8-m diameter on-axis**

# Summary

- If you want the next flagship to do your science, get involved
- How to get involved - join a subworking group
  - https://habitableworldsobservatory.org/about
- Questions?
  - Ask now!
  - Or find us this week: Jon Arenberg, Eric Burns, Edmund Hodges-Kluck, Rob Petre,
  - Or Jessica Gaskin as another representative from the high energy side