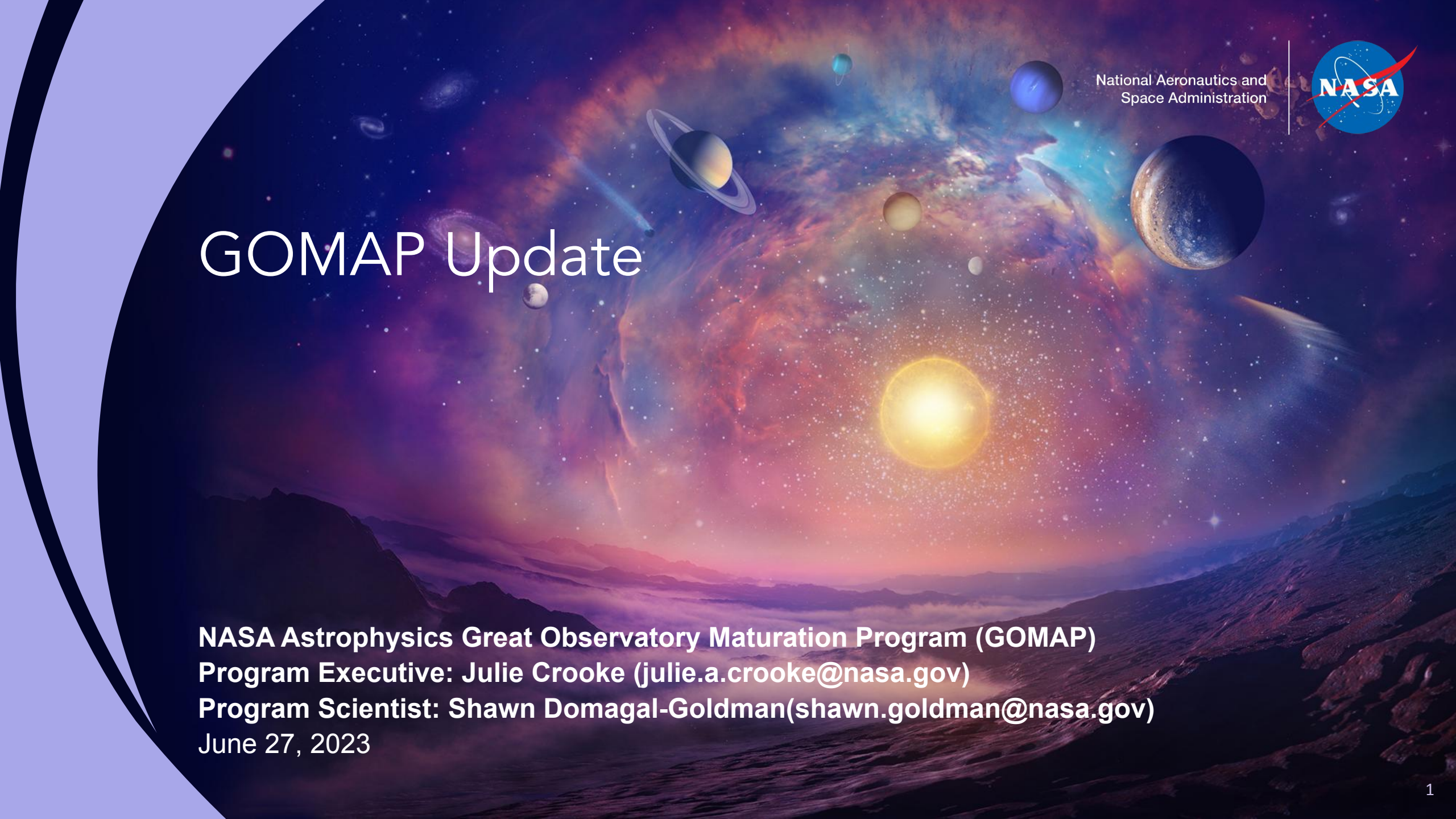


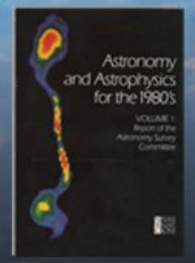
GOMAP Update

NASA Astrophysics Great Observatory Maturation Program (GOMAP)
Program Executive: Julie Crooke (julie.a.crooke@nasa.gov)
Program Scientist: Shawn Domagal-Goldman(shawn.goldman@nasa.gov)
June 27, 2023

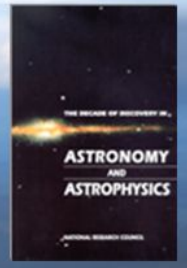
Astrophysics

Decadal Survey Missions

1972
Decadal Survey
Hubble



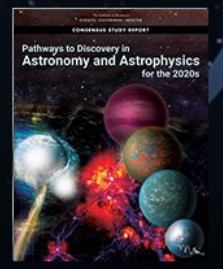
1982
Decadal Survey
Chandra



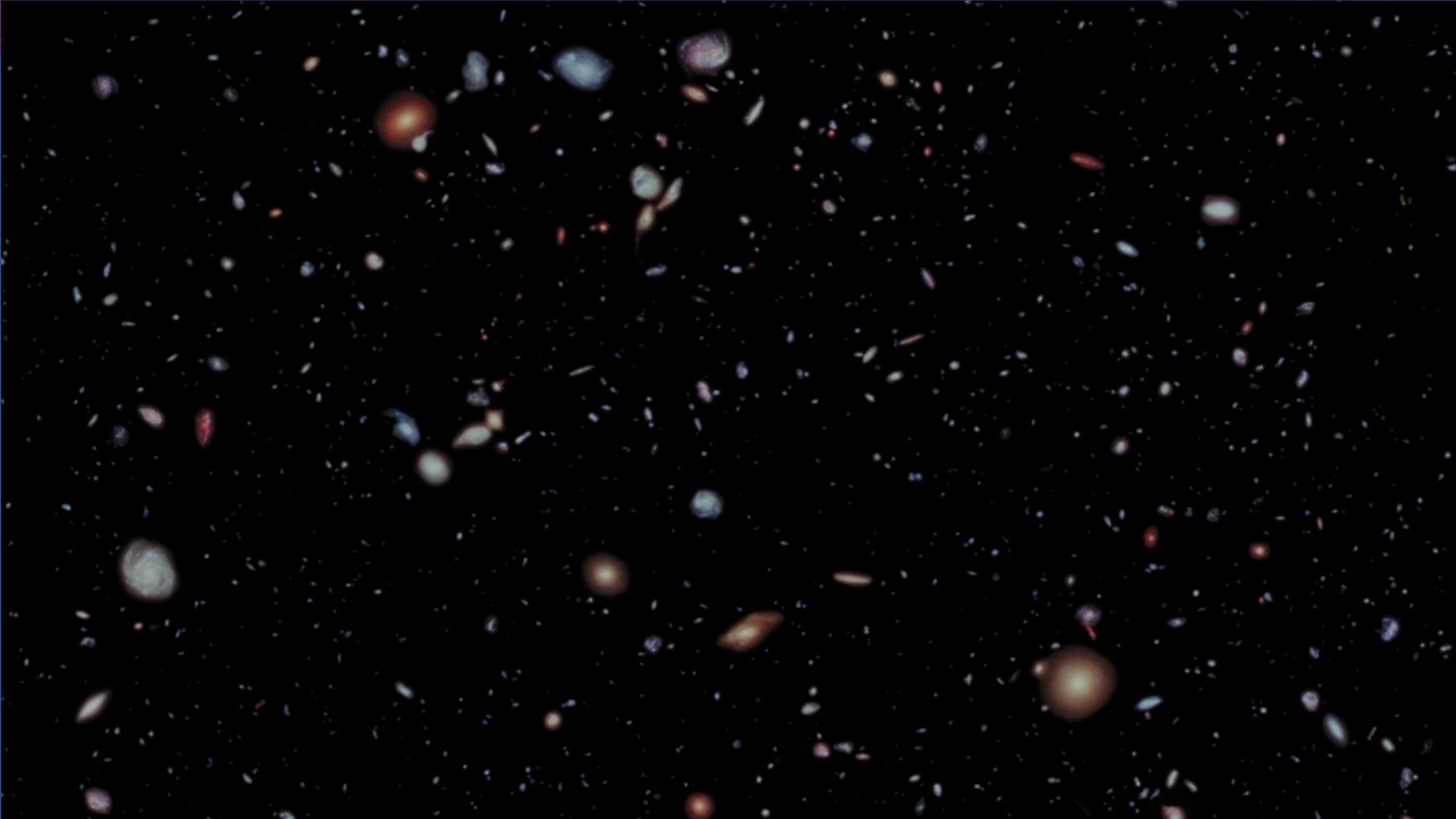
1991
Decadal Survey
Spitzer

2001
Decadal Survey
Webb

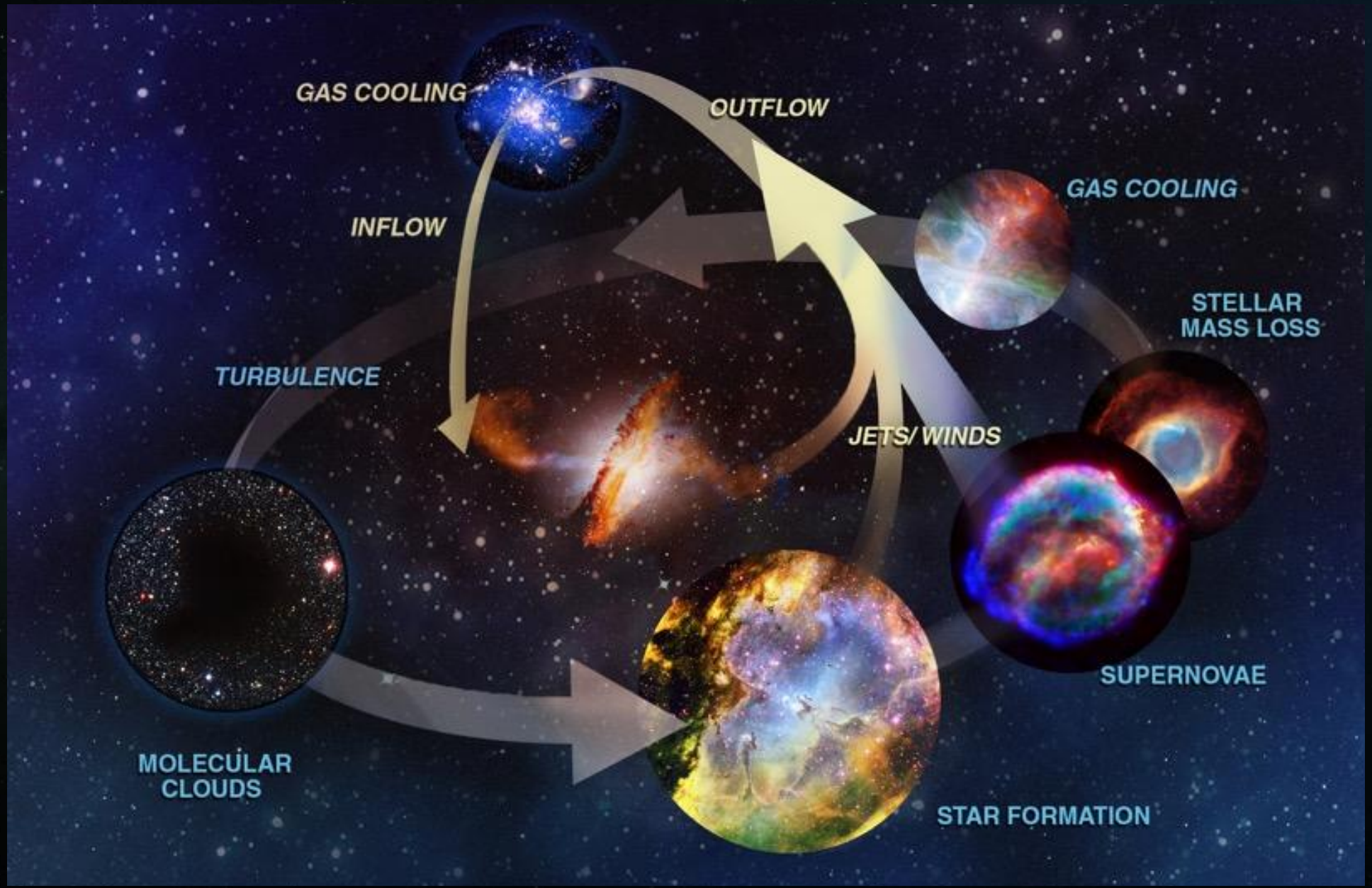
2010
Decadal Survey
Roman



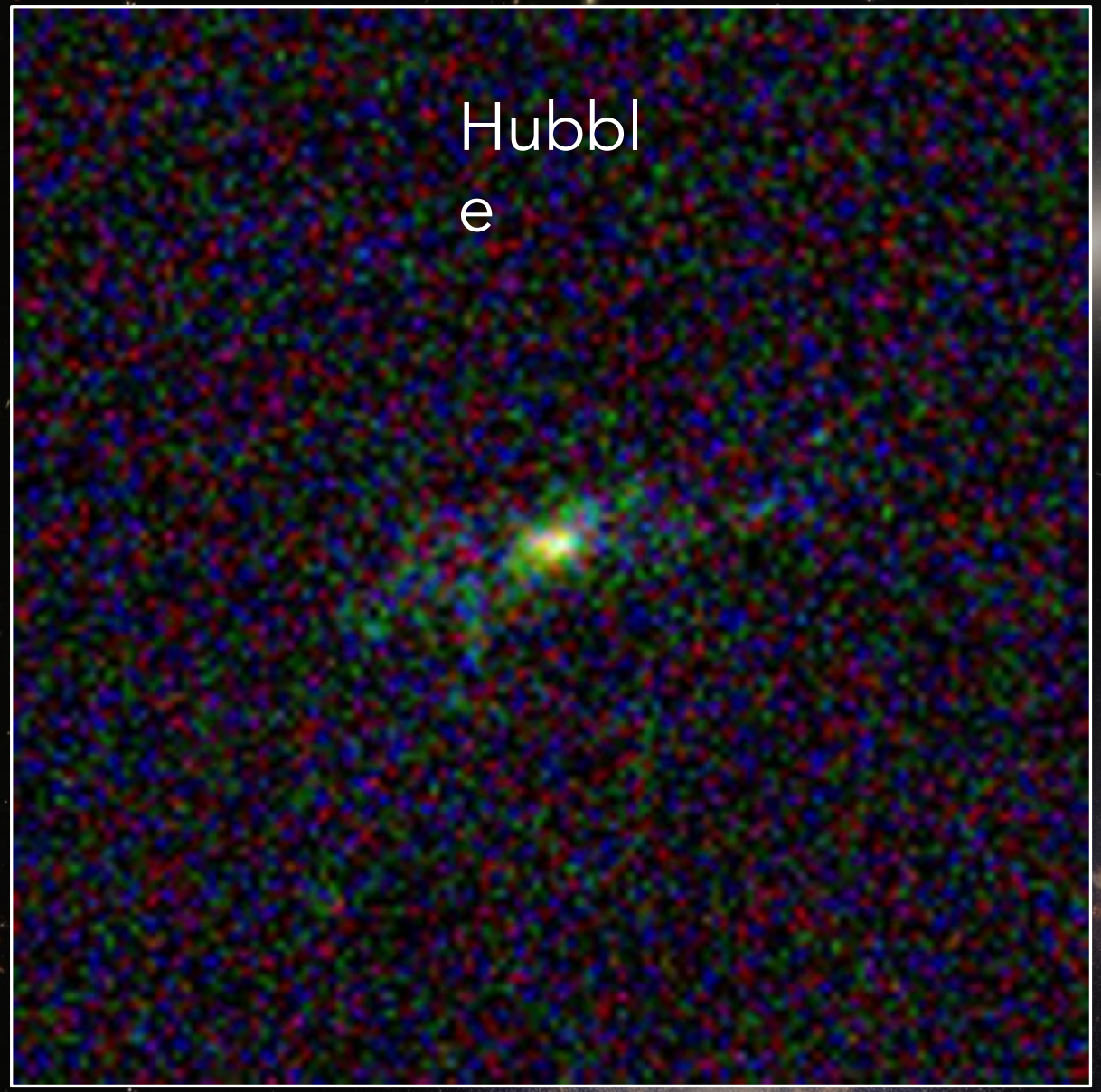
2021
Decadal Survey

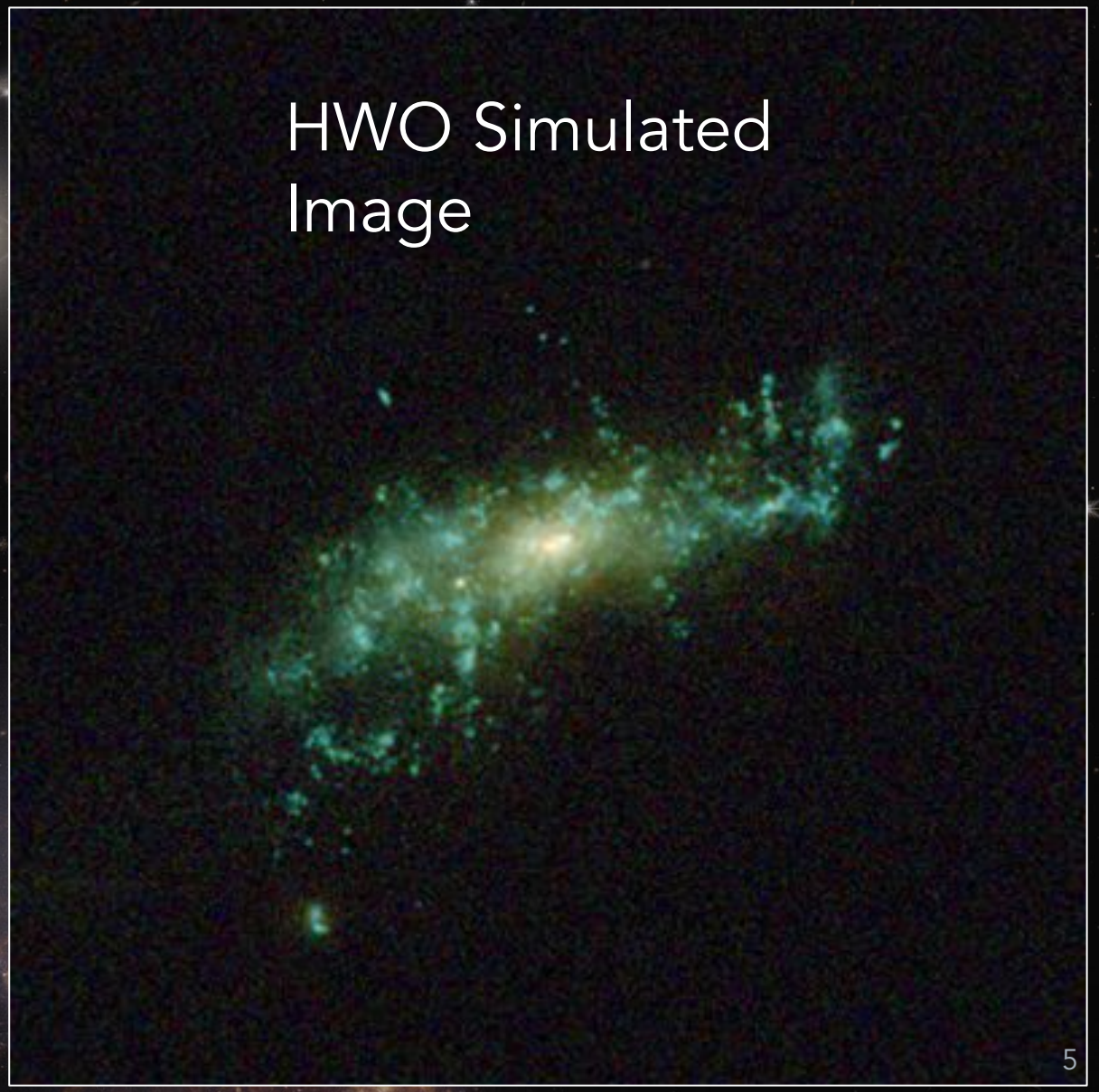


Studying the Lifecycles of Galaxies

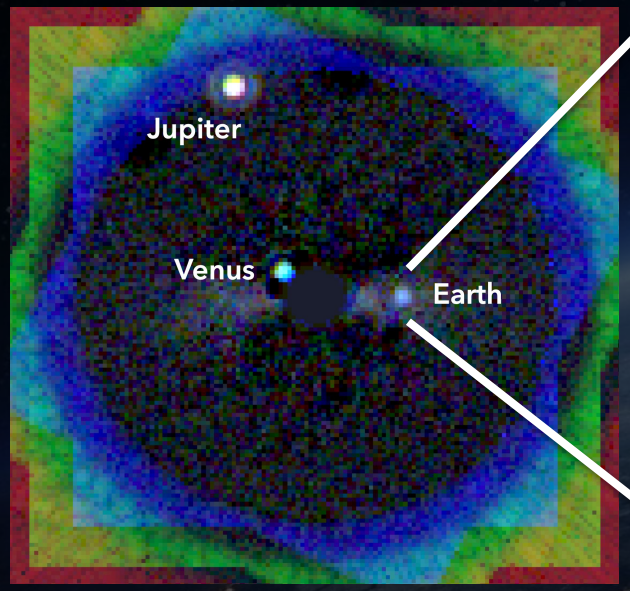


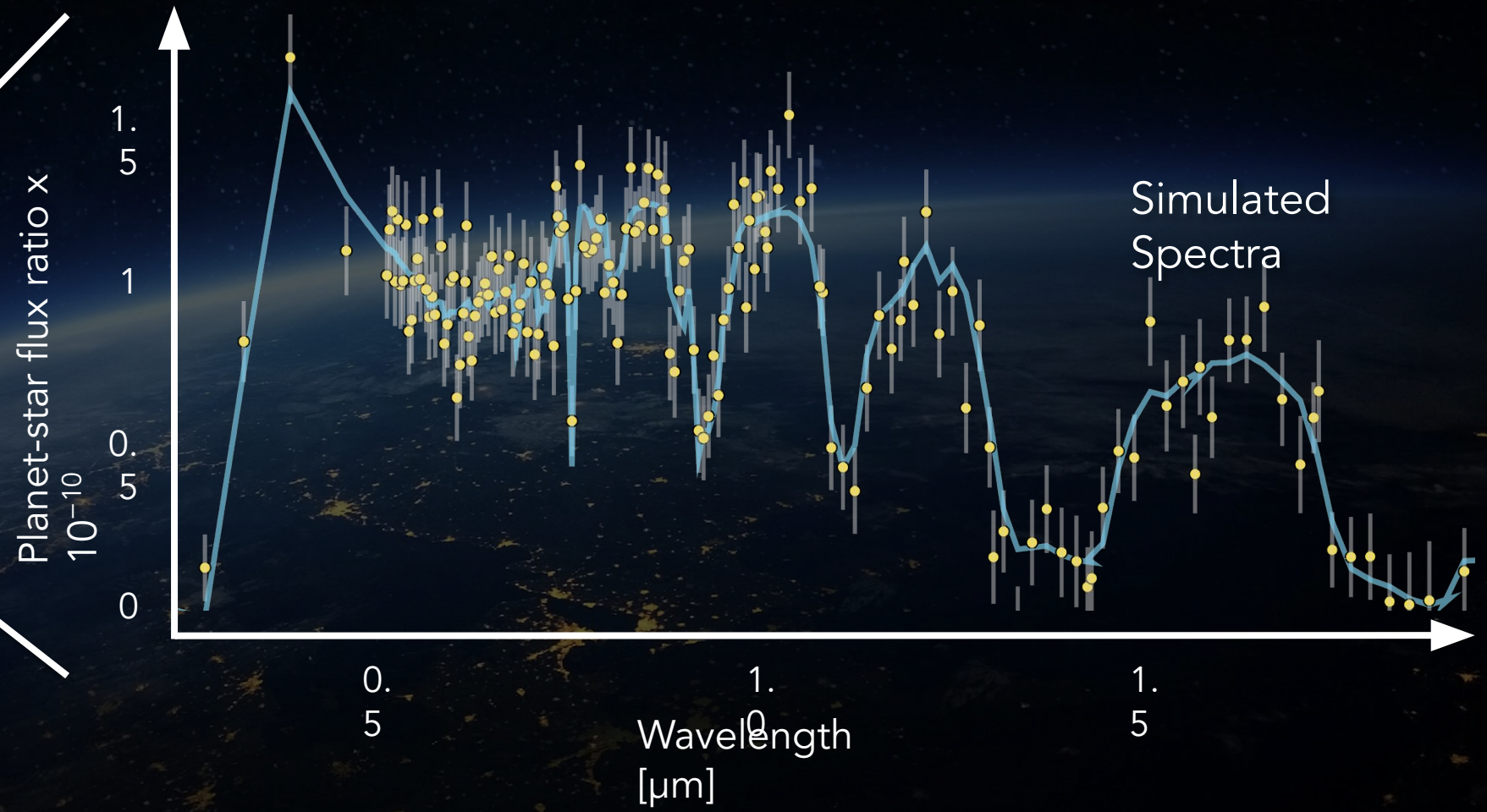
Probing the Properties of Dark Matter with Dwarf Galaxies





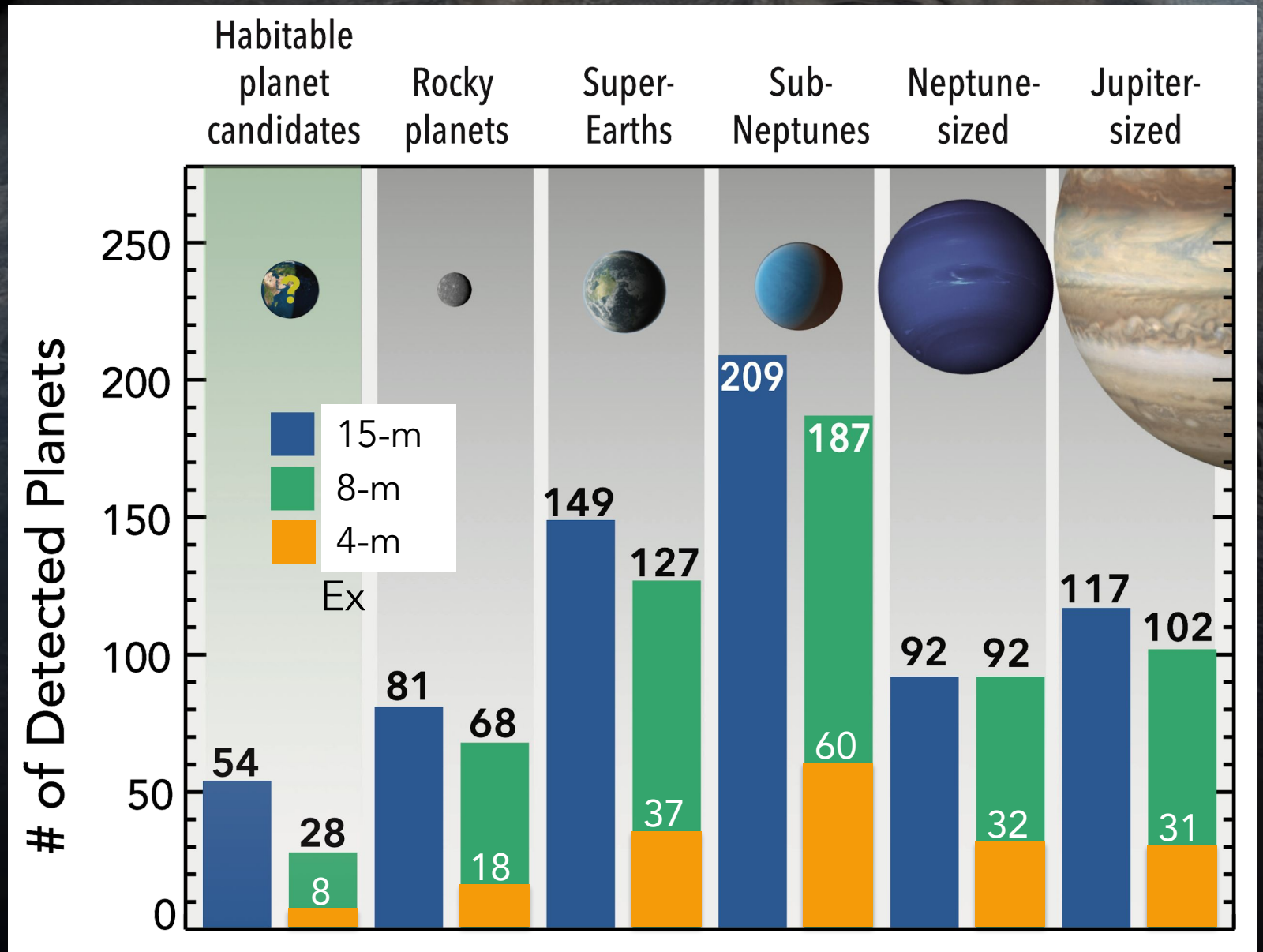
Searching for Life Outside the Solar System





Analyze light directly reflected by the planet, with little or no starlight mixed in

Exploring the Diverse Range of Exoplanets



HWO can reveal what these exotic worlds are really like

Why GOMAP? Decades of research-based consensus on megaprojects

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

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.

TABLE OF CONTENTS

1. DEFINITION OF FLAGSHIP MISSIONS 1
2. BENEFITS OF FLAGSHIP MISSIONS 2
3. DIFFICULTY IN ESTIMATING FLAGSHIPS 2
4. FLAGSHIP COST GROWTH 3
5. COULD COSTS HAVE BEEN ANTICIPATED? 7
6. A POTENTIAL NEW APPROACH 7
7. SUMMARY 10
ACKNOWLEDGEMENTS 10
ACRONYMS 10
REFERENCES 10
BIOGRAPHY 12

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.

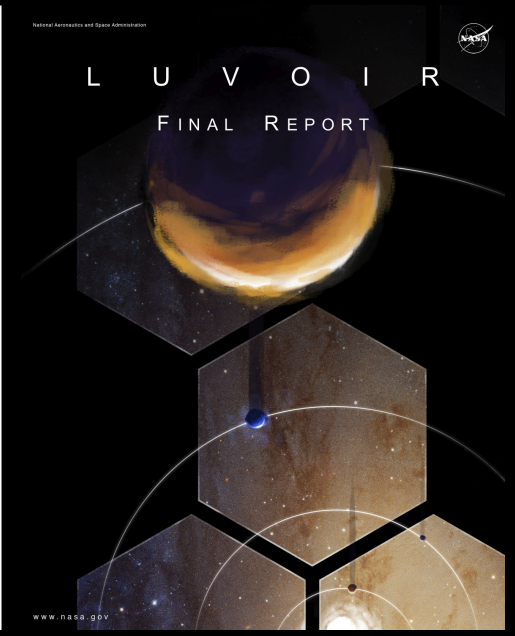
Figure 1 shows typical examples of NASA Flagship missions such as Viking, Galileo, the Hubble Space Telescope (HST), and others relative to their launch date and development cost. As shown in Figure 1, Flagship mission are typically developed on the order of every 10 years and have a cost greater than $2B fiscal year 2017. The development cost is from the start of preliminary development at the beginning of Phase B through launch and is taken from NASA historical public budget documents and then inflated to fiscal year 2017 equivalent dollars (FY17$). [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

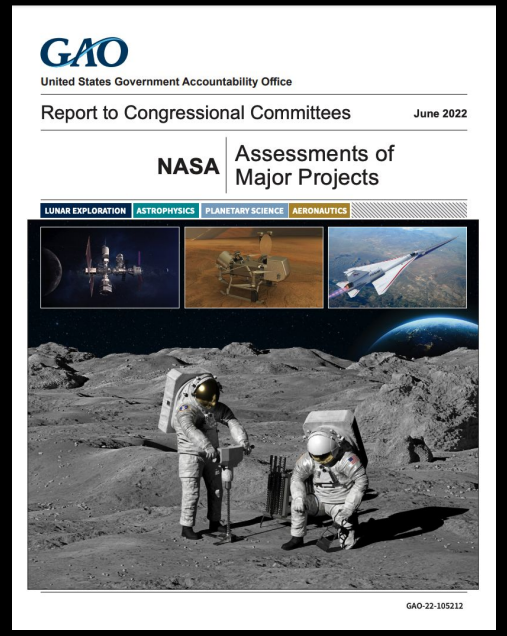
978-1-5386-6854-2/19/$31.00 ©2019 IEEE

1

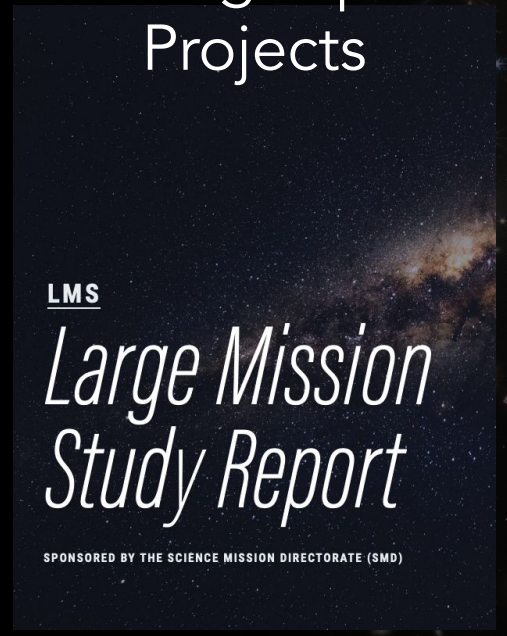
Mission Concept Reports



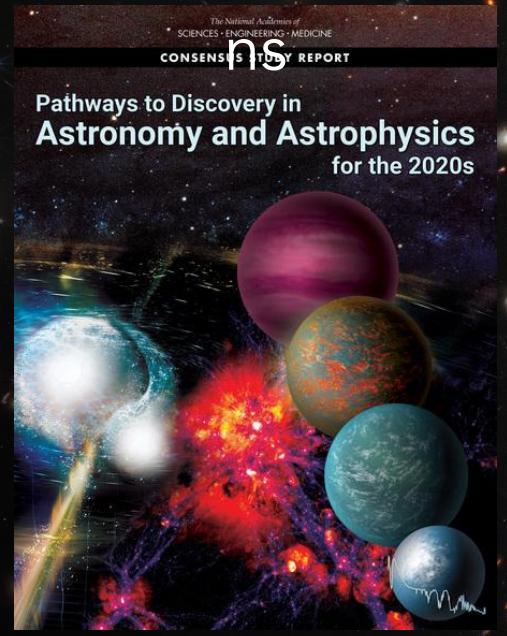
GAO Report on Major Projects



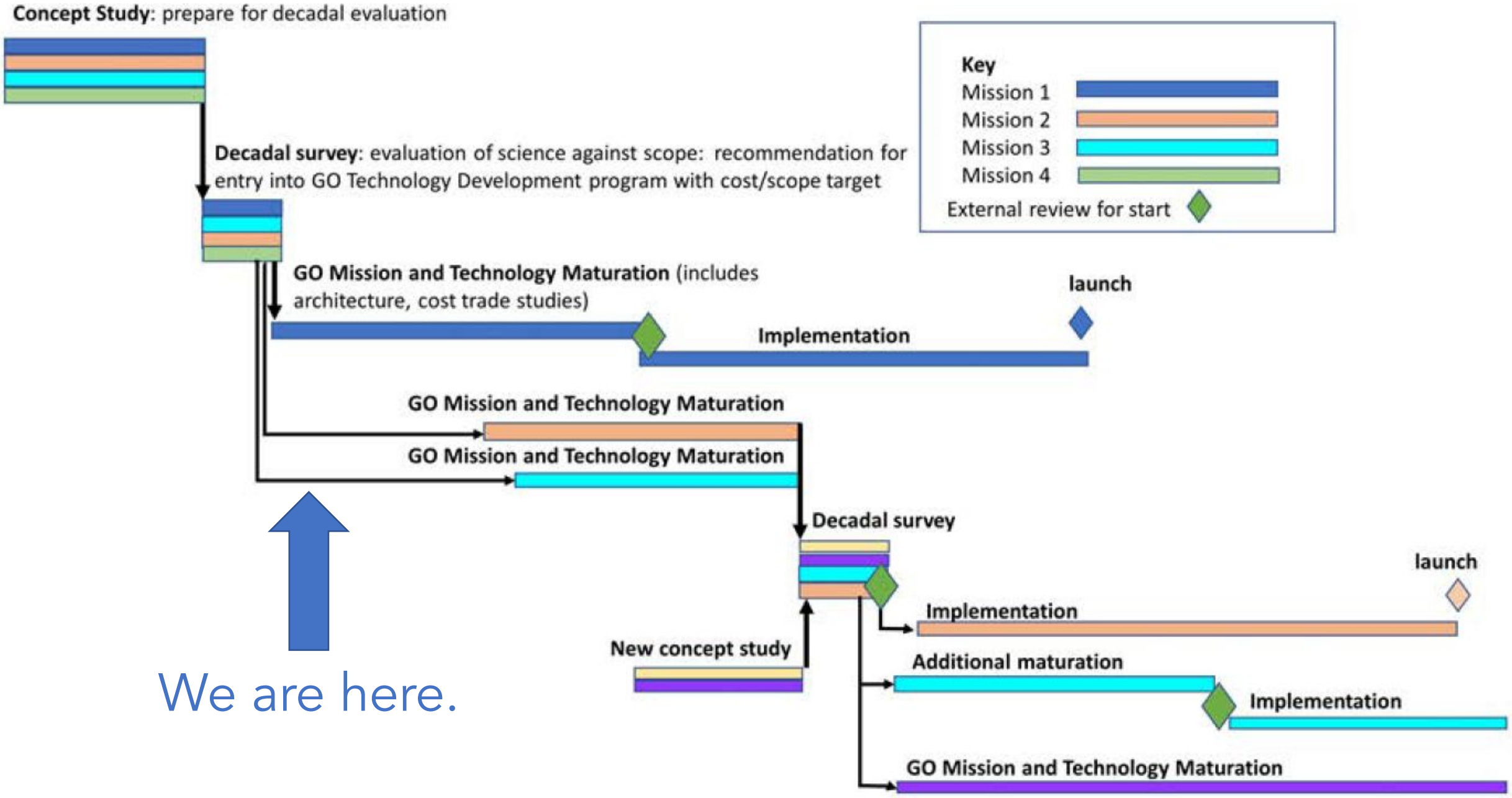
SMD Internal Study on Flagship Projects



National Academy Recommendations



A variety of documents from internal, external, and oversight groups all point to a consistent set of problems & solutions for large/flagship projects, across sectors

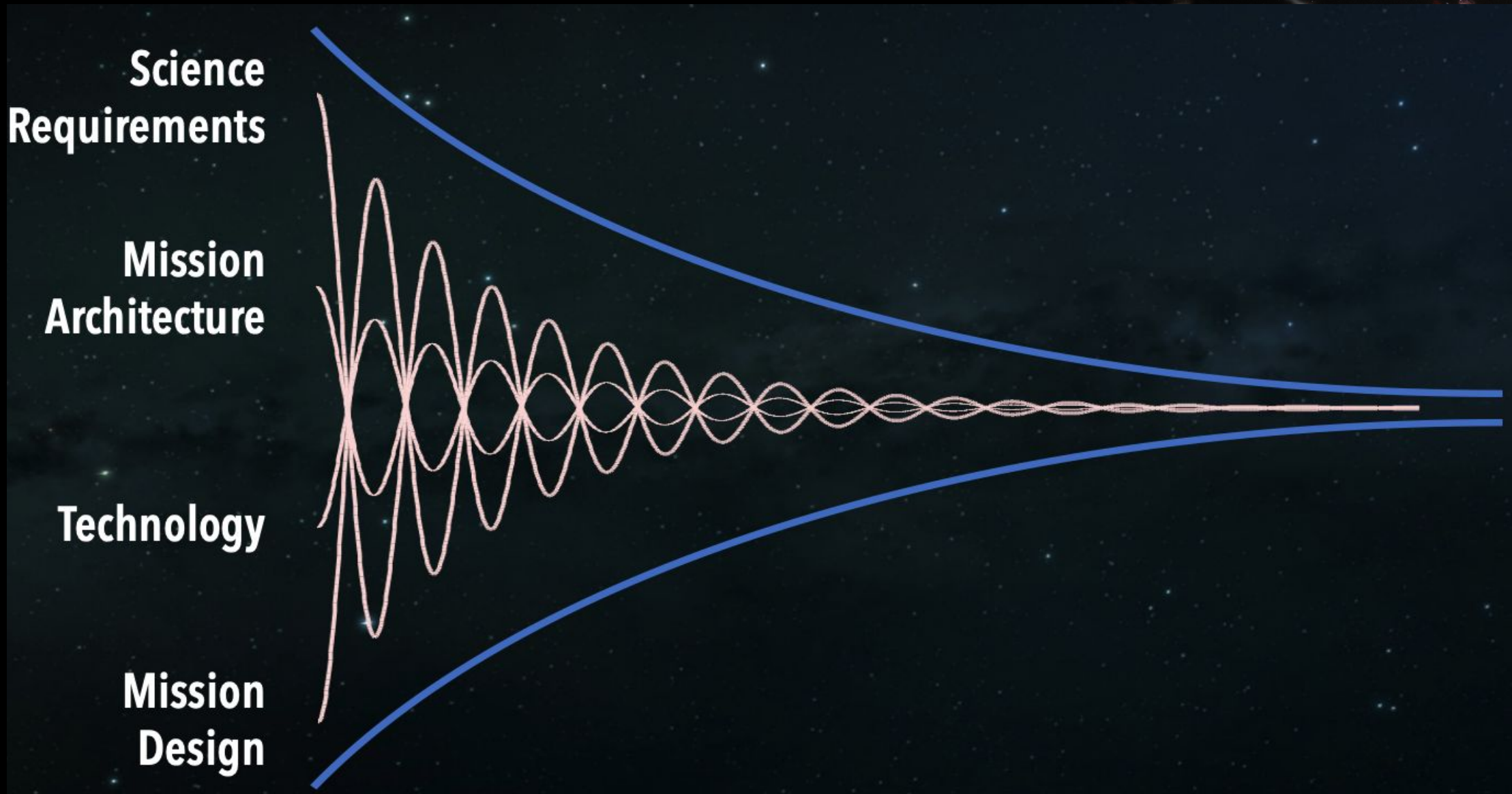

Concept Study: prepare for decadal evaluation
Key
Mission 1
Mission 2
Mission 3
Mission 4
External review for start
Decadal survey: evaluation of science against scope: recommendation for entry into GO Technology Development program with cost/scope target
GO Mission and Technology Maturation (includes architecture, cost trade studies)
launch
Implementation
GO Mission and Technology Maturation
GO Mission and Technology Maturation
Decadal survey
launch
Implementation
New concept study
Additional maturation
Implementation
GO Mission and Technology Maturation
We are here.

The Habitable Worlds Observatory:

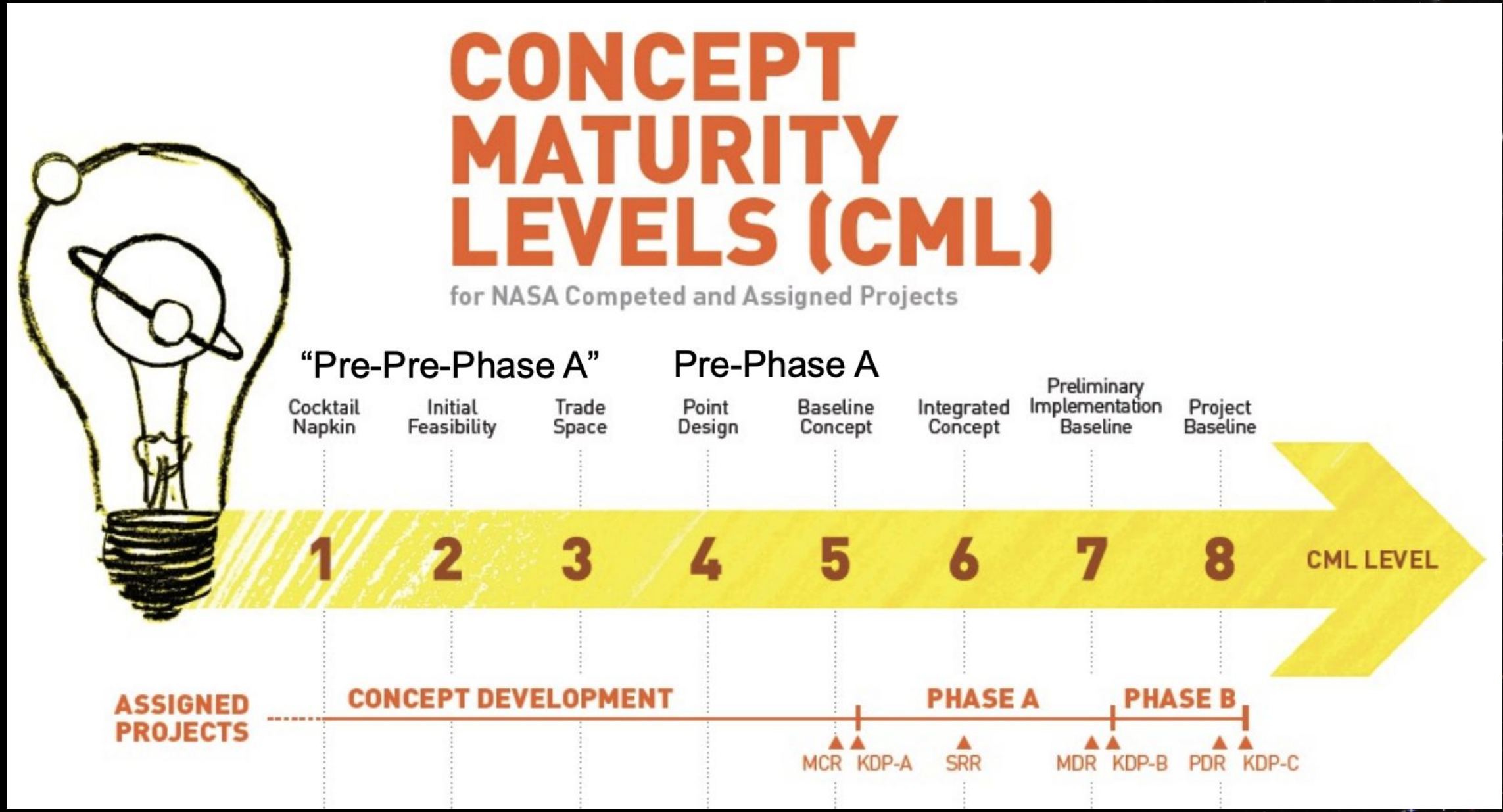
Big Picture Strategy

- **Build to schedule**: Mission Level **1 Requirement - like planetary**
- **Evolve technology from what we have done before**:
  - Build upon current NASA investments and TRL-9 technology
  - Segmented optical telescope system from JWST
  - Coronagraph from Roman‘s coronagraphic imager program
- **Next Generation Rockets**:
  - Larger telescope aperture sizes
  - Leverage opportunities for mass & volume trades
- **Planned Servicing**: Robotic servicing at L2
- **Robust Margins**: Large scientific, technical, and programmatic margins
- **Mature technologies first**: Reduce risk by fully maturing the technologies prior to development phase.

Advancing the HWO Concept

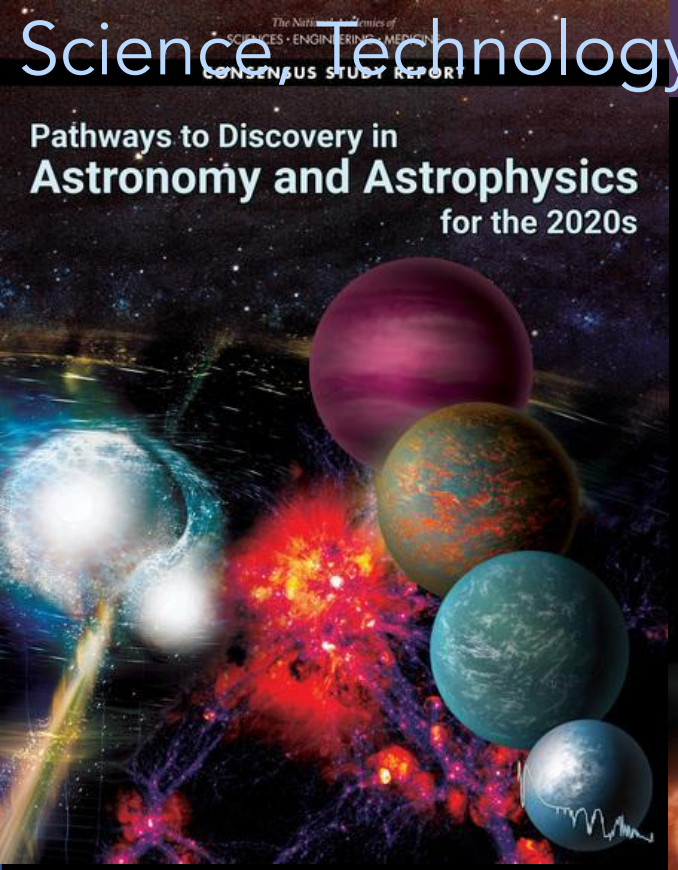


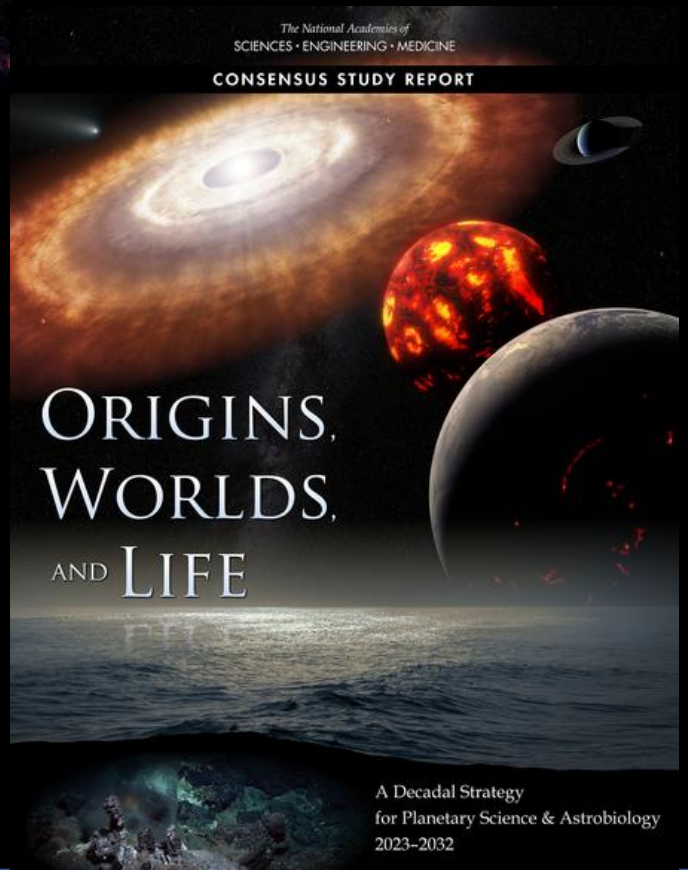
Advancing the HWO Concept



https://exoplanets.nasa.gov/internal_resources/2232_Session-2_1_Linking_Science_and_Mission_Architecture-John_Ziemer.pdf

Science Technology, Architecture Review Team (START)





Which decadal science questions can HWO help address?

What observations do we need to answer those questions?

What capabilities will deliver those observations?

What performance can we expect?

Where do performance breakpoints exist?

What models do we need to predict performance?

Technical Assessment Group (TAG)

What architecture trades remain?

How are those trades related/coupled to each other?

Which trades are the most important to study now?

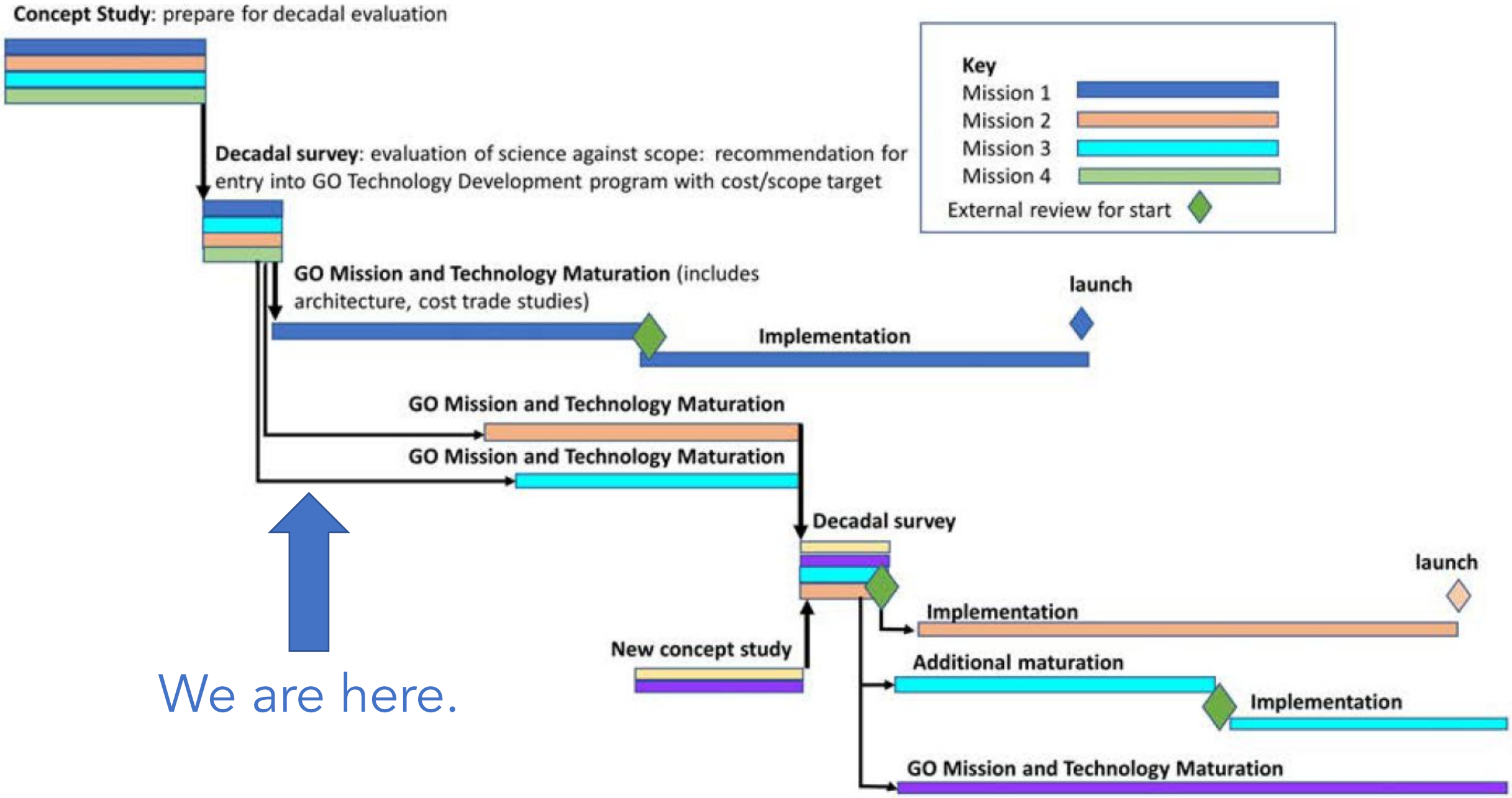
What are the technologies associated with those trades?

What cost/schedule risks exist for those trades?

How might those risks be mitigated?

How can external partners be involved?


esa
#UnfoldTheUniverse
EssilorLuxottica
EssilorLuxottica


Concept Study: prepare for decadal evaluation
Key
Mission 1
Mission 2
Mission 3
Mission 4
External review for start
Decadal survey: evaluation of science against scope: recommendation for entry into GO Technology Development program with cost/scope target
GO Mission and Technology Maturation (includes architecture, cost trade studies)
launch
Implementation
GO Mission and Technology Maturation
GO Mission and Technology Maturation
Decadal survey
launch
Implementation
New concept study
Additional maturation
Implementation
GO Mission and Technology Maturation
We are here.

Near-Term HWO

Goal:
- Efficient project ready for funding

Objectives:
- Ready for formal Pre-Phase A
- Concept Maturity Level 3
  Technologies at TRL4
- Science goals & objectives explored

Roadmaps for:
- Concept Maturity Level 5
- Technology Readiness Level ≥ 6
- Science Traceability Matrix Definition

HWO By Astro2030

Goal:
- Successful independent assessment

Objectives:
- Ready for mission formulation
- Concept Maturity Level 5
- Technologies ≥ TRL 5
- Science Traceability Matrix finalized

Roadmaps for:
- Concept Maturity Level 8
- Technology Readiness Level ≥ 6

Near-Term FGOs 2,3

Goal:

- Continue advancing science/technology development via opportunities (probes, Explorers, suborbital missions, technologies)

Objectives:

- Technologies development
- Precursor science

FGOs 2,3 By Astro2030

Goal:

- Prepare and be ready for prioritization at Astro2030

Roadmaps for:

- Concept Maturity Level 5
- Technologies ≥ TRL 6
- Science Traceability Matrix definition

Range of opportunities to mature science and technologies:

- Probes
- Explorers
- Suborbital missions
- Technology development

Before HWO Project

HWO

- Science, Technology, Architecture Review Team (START)
  - Develop left 2 columns of Science Traceability Matrix (STM)
- Technical Assessment Group
  - Explore trade space in context of current landscape opportunities
- Precursor science proposals
- SAT Competed Technology Calls
- Technology Roadmapping via Astrophysics Program Offices

FGO-2, FGO-3:

- Precursor science proposals
- SAT Competed Technology Calls

With HWO Project

HWO

- Projectized Pre-Phase A and Phase A – managed by NASA HQ Astrophysics Strategic Mission Program (ASMP)

Pre-2030 Decadal: FGO-2, FGO-3

- Technology Roadmapping
- Precursor science proposals
- SAT Competed Technology Calls
- Pre-Astro2030 Study Teams

How who gets involve with HWO

Community Activities

- Program Analysis Groups
  - Science Analysis Groups
  - Science Interest Groups
- START meetings (likely to be open)

NASA-formed groups

- Science, Technology, Architecture Review Team
- Technology Roadmapping Groups
- Science Yields and Metrics Teams
- Mentorship program (details TBD)

Competed Calls

- Astrophysics Decadal Survey Precursor Science (ROSES)
- Strategic Astrophysics Technologies (ROSES)
- EPRV Foundation Science (ROSES)
- Future technology calls (ROSES)
- Future architecture deep dive calls (TBD)

IDEA for GOMAP

Now:

- Selecting START co-chairs/members with objective criteria including ideas for inclusivity, and with diversity of team in mind

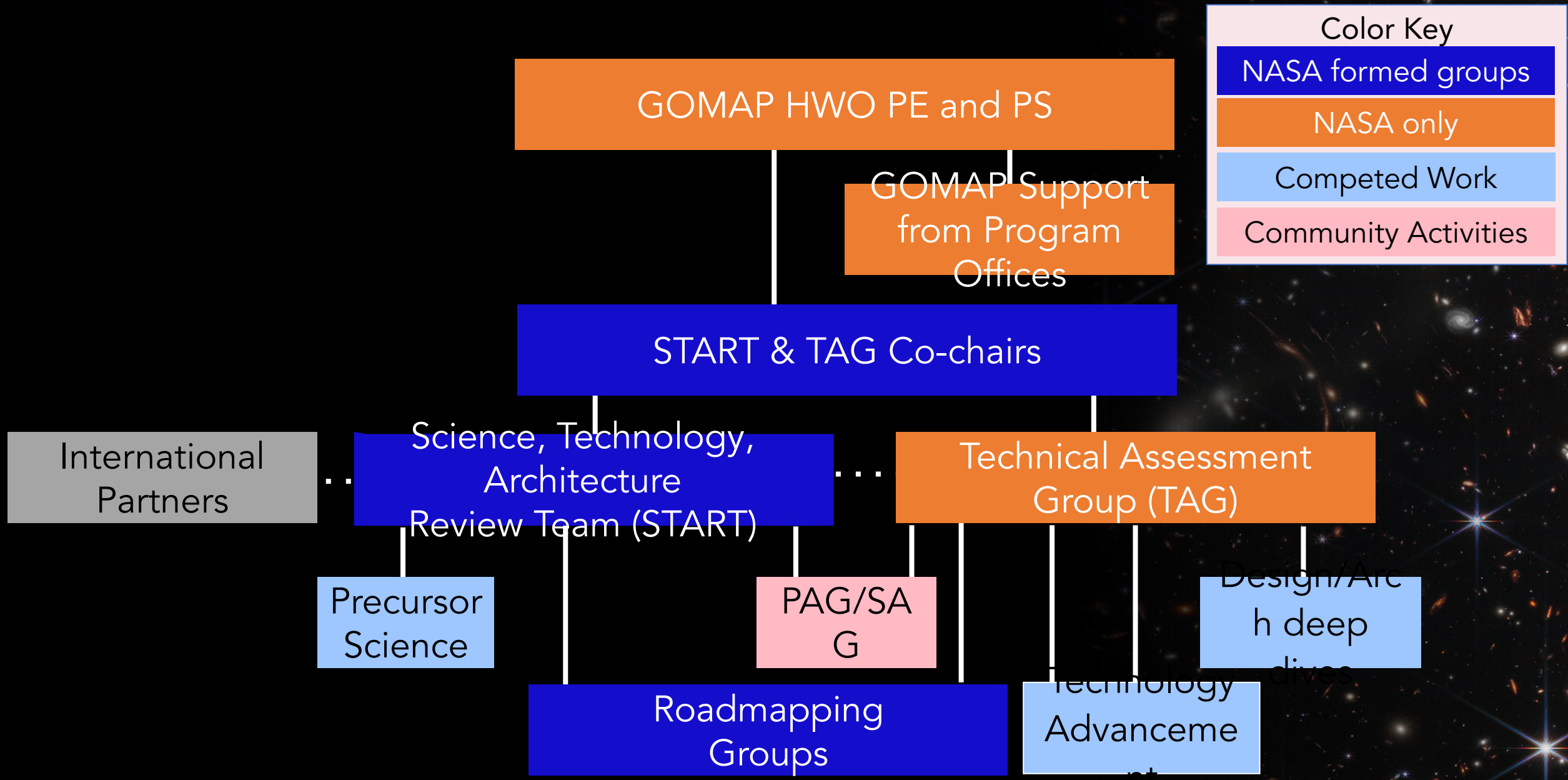
Soon:

- Incorporate IDEA into START and TAG meetings and activities. Specific plans to be worked with co-leads and ultimately members of those groups.

Long-term:

- Develop IDEA plan for HWO. Would like to work with external partners on this to institute "one-team culture" on HWO, and to help ensure IDEA principles are present throughout project.

How who gets involve with HWO



Questions and more information

NASA Astrophysics Statement of Principles:
go.nasa.gov/3Kwn07s

NASA GOMAP website:
go.nasa.gov/4107ZzC

julie.a.crooke@nasa.gov
shawn.goldman@nasa.gov