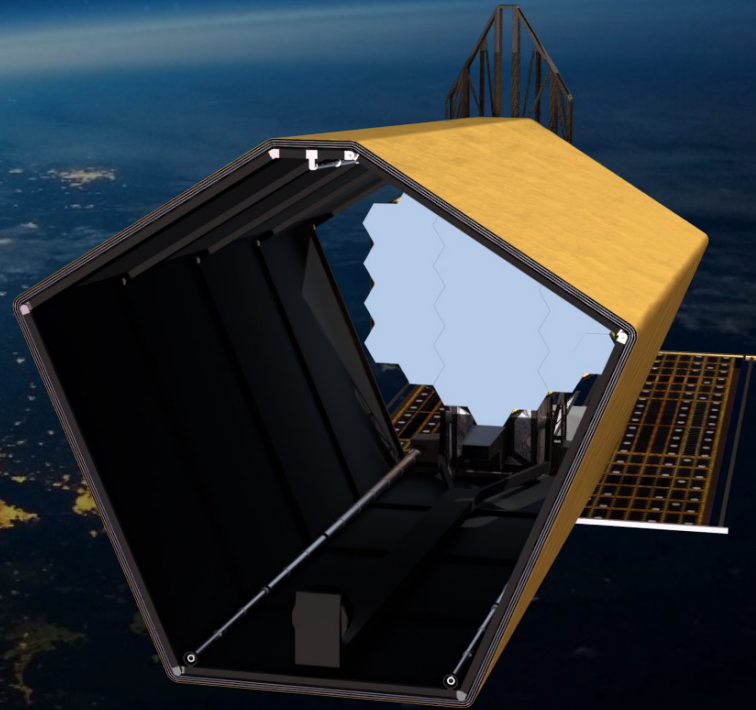


# MATURING THE HABITABLE WORLDS OBSERVATORY

Dr. Aki Roberge

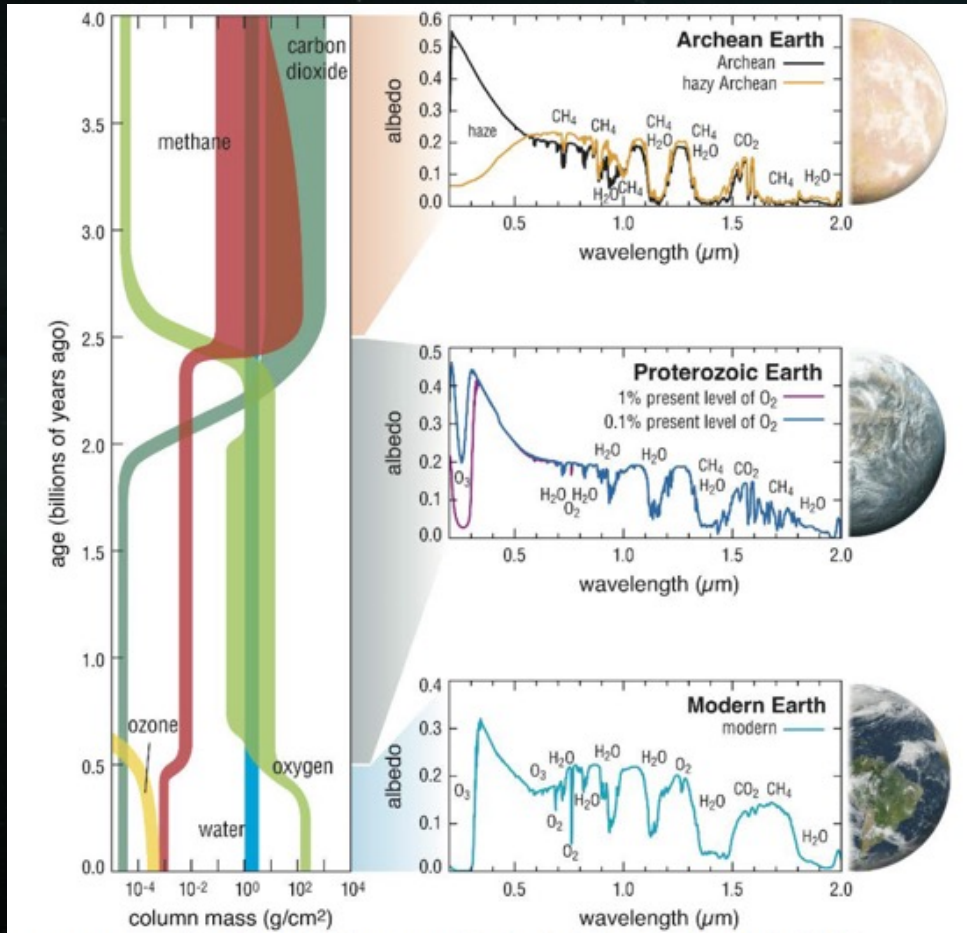
NASA Goddard Space Flight Center

*NUVA eMeeting – Oct 24, 2023*

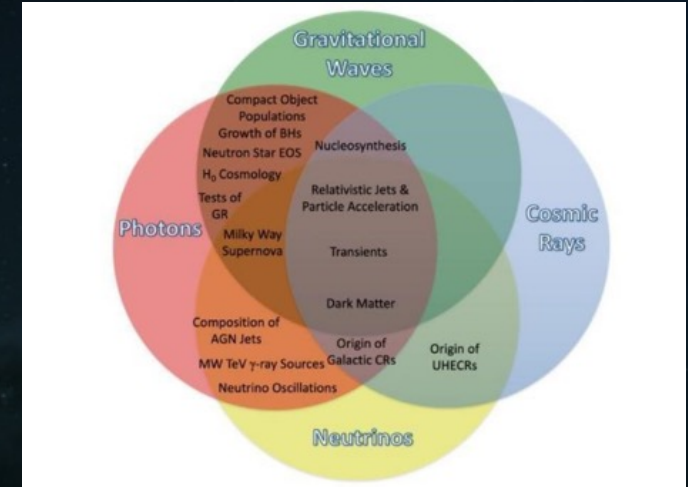


# ASTRO2020 SCIENCE THEMES

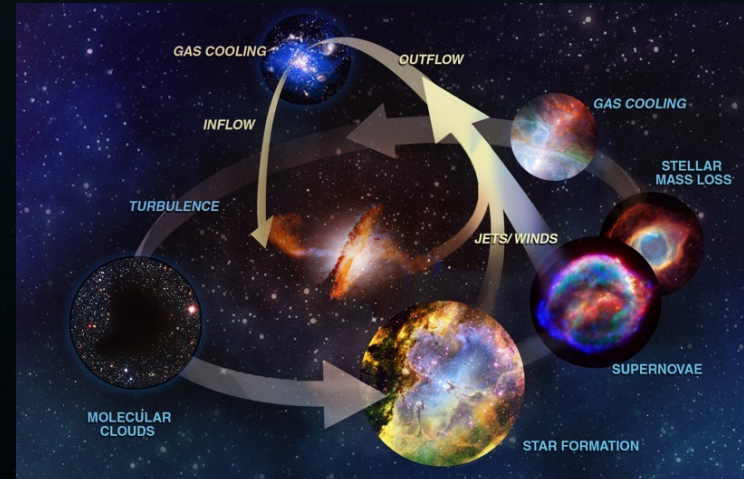
## Worlds and Suns in Context: Pathways to Habitable Planets



## New Messengers & New Physics: New Windows on the Dynamic Universe




## Cosmic Ecosystems: Unveiling the Drivers of Galaxy Growth



# WHAT IS HABITABLE WORLDS OBSERVATORY?

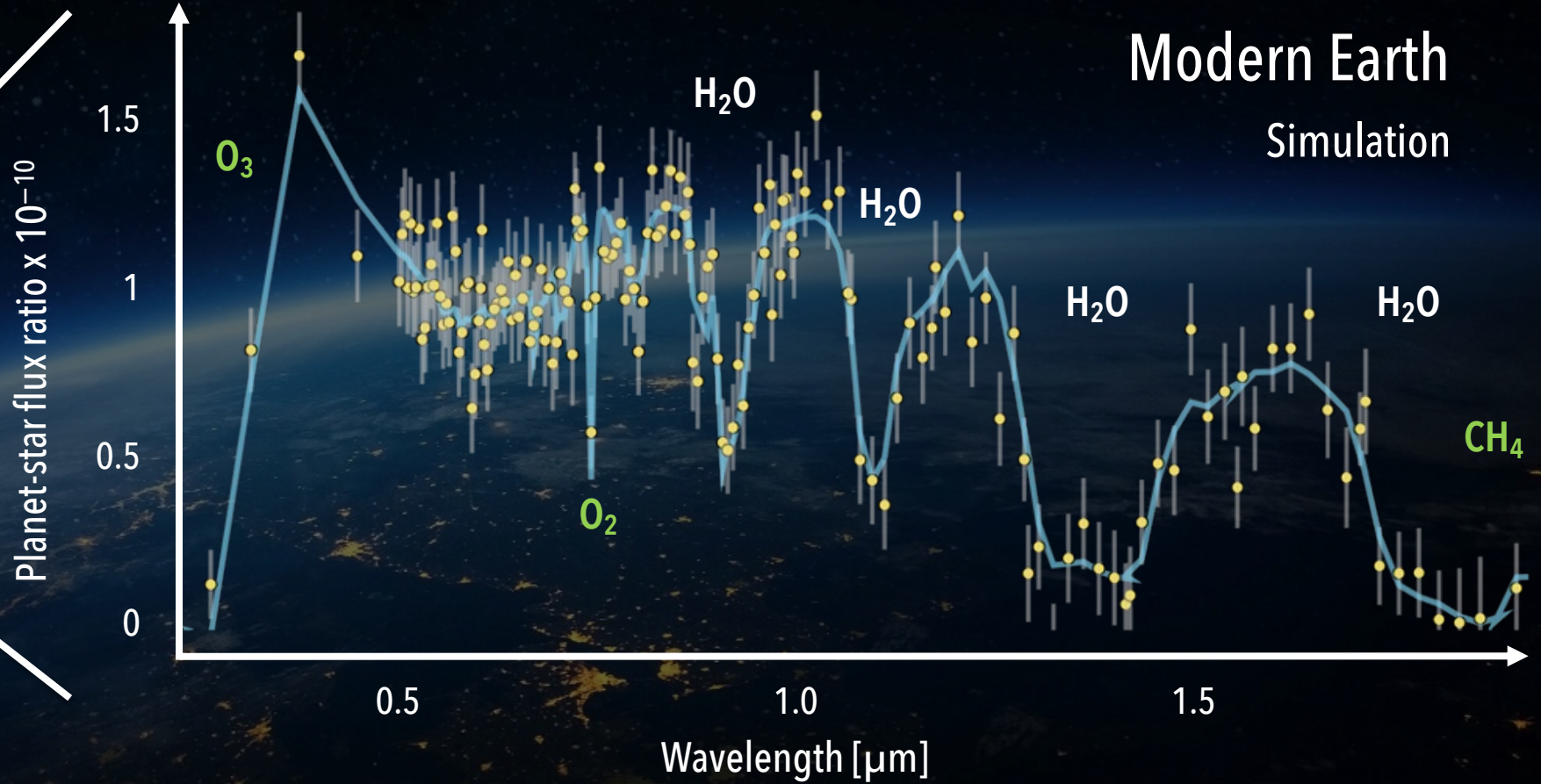
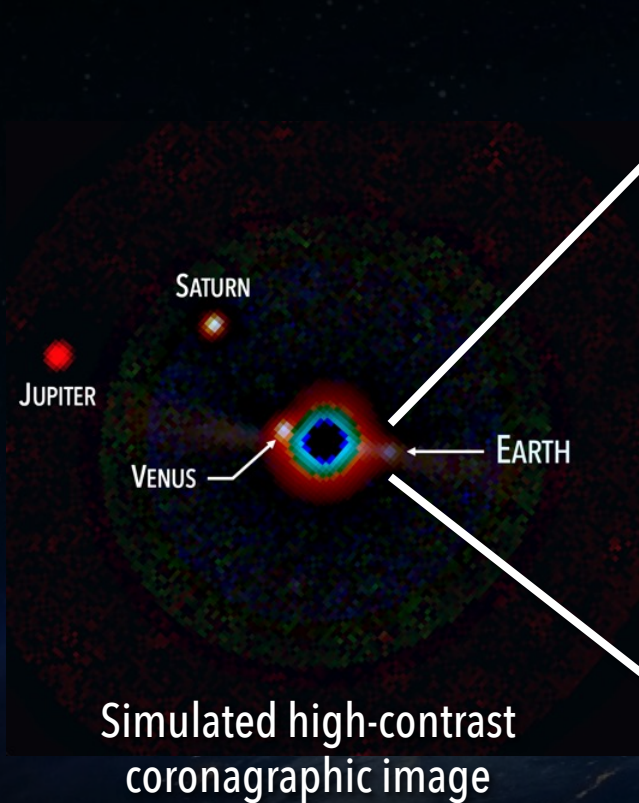
Large UV / optical / infrared space telescope  
to search for life on exoplanets and enable transformative astrophysics



"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)*

# THE SEARCH FOR LIFE



Analyze light directly reflected by the planet, with little or no starlight mixed in  
Key technical challenge for HabWorlds

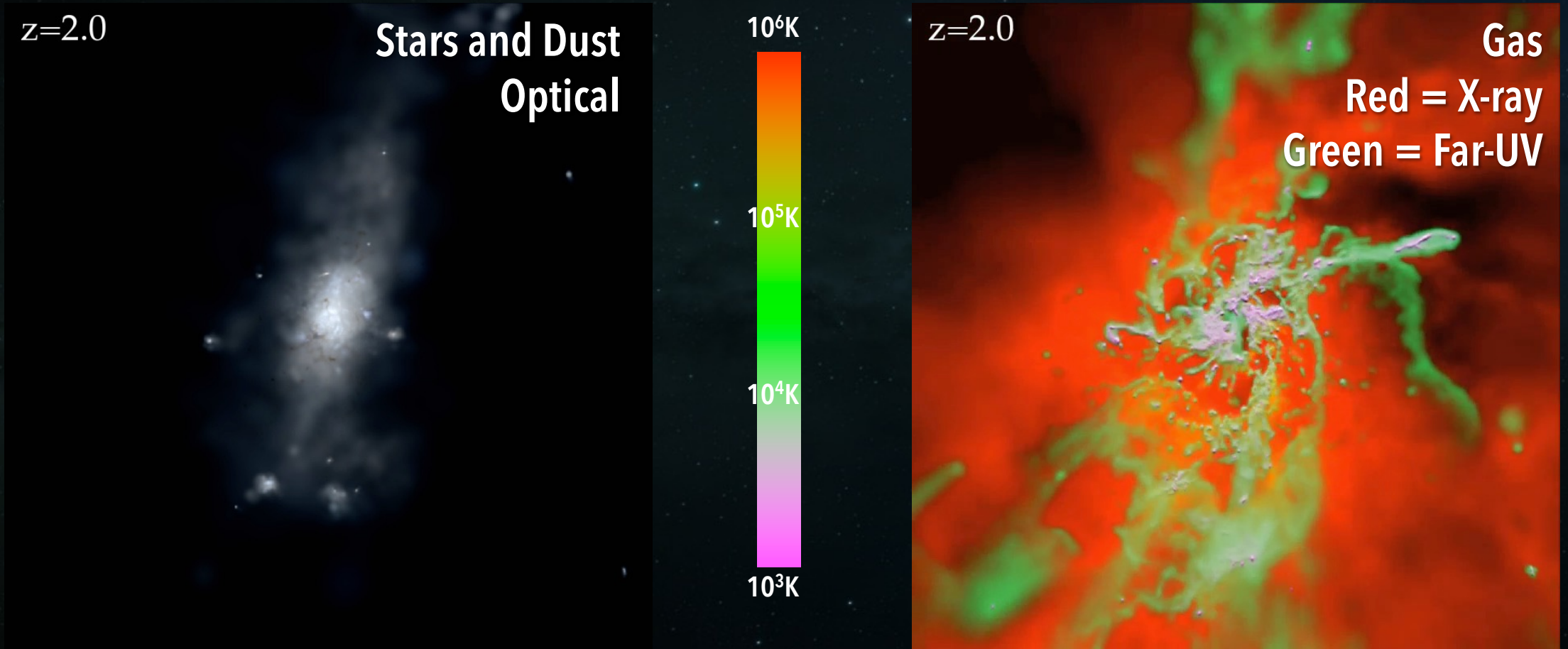
# THE BUILDING BLOCKS OF GALAXIES

Low-mass dwarf galaxy at redshift = 2  
10.2 billion years ago, 25% of current age of the universe



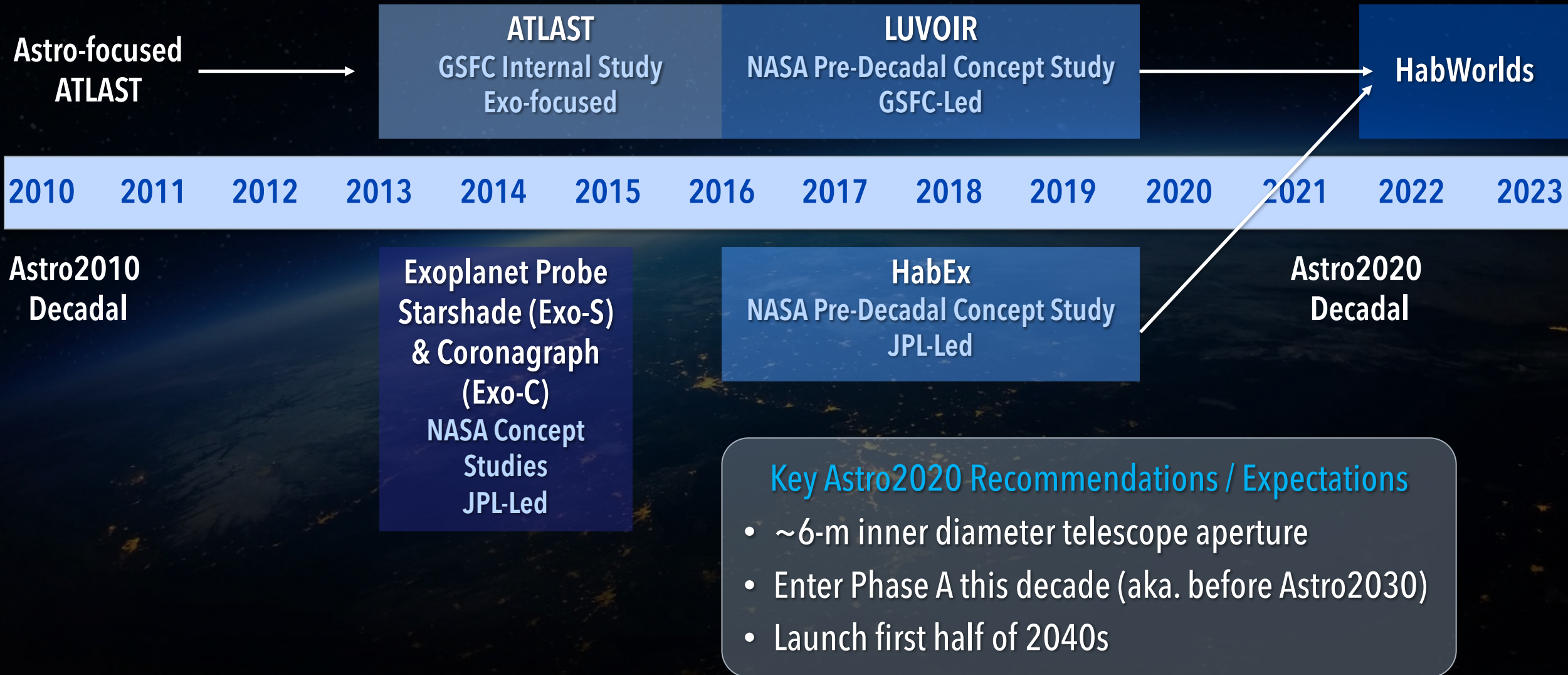
# THE CYCLES OF MATTER

Illustris simulation  
Credit: G. Snyder (STScI)



Key question: How far into the far-UV should HabWorlds go?

# BACKGROUND LEADING TO HABWORLDS





L U V O I R

H A B E X





# LUVOIR ARCHITECTURES

Two LUVOIR designs

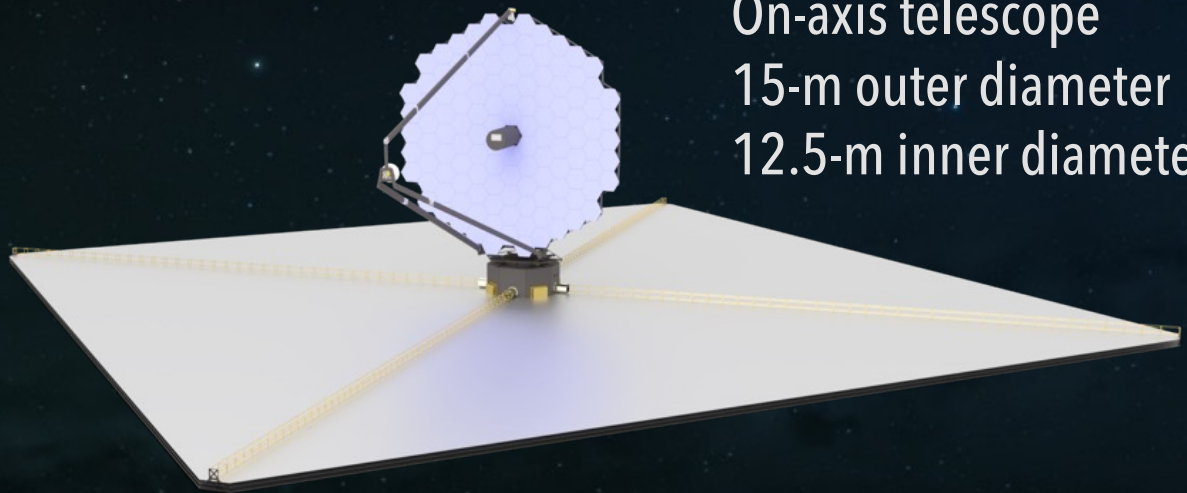
Total wavelength range: 100 nm - 2.5  $\mu$ m

Four instruments (next slides)

Serviceable and upgradable

5-year prime mission duration, 10 years of consumables

25-year lifetime goal for non-serviceable components

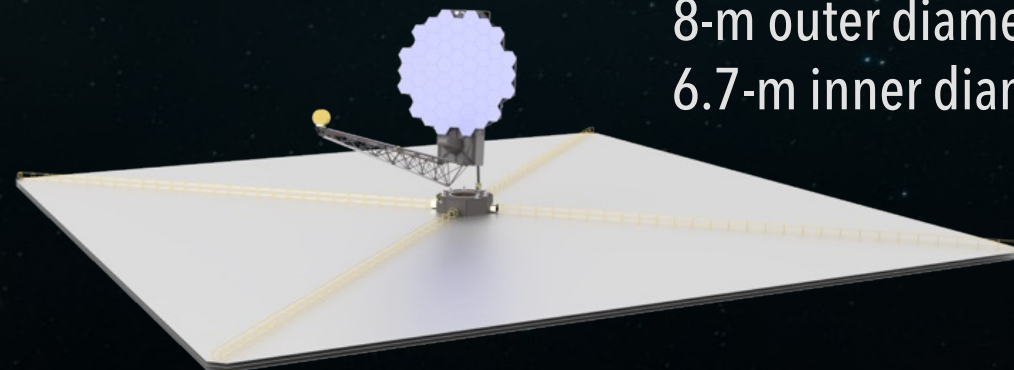


LUVOIR-A

On-axis telescope

15-m outer diameter

12.5-m inner diameter



LUVOIR-B

Off-axis telescope

8-m outer diameter

6.7-m inner diameter



# THE LUVOIR CANDIDATE INSTRUMENTS

## ECLIPS

Extreme Coronagraph for Living Planetary Systems

Coronagraph with imaging and imaging spectroscopy

Bandpass	200-2000 nm
Contrast	$1 \times 10^{-10}$
IWA	$3.5 \lambda/D$
OWA	$64 \lambda/D$
R ( $\lambda/\Delta\lambda$ )	Vis: 140 NIR: 70, 200

## HDI

High-Definition Imager

Wide field imager with simultaneous UV/Vis and NIR coverage

Bandpass	200-2500 nm
FoV	$3' \times 2'$
67 science filters + grism	
Nyquist sampled	
High-precision astrometry	

## LUMOS

LUVOIR Ultraviolet Multi-Object Spectrograph

UV/Vis multi-object spectrograph and FUV imager

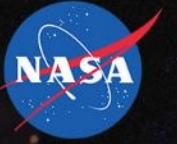
Bandpass	100-1000 nm
MOS FoV	$2' \times 2'$
Apertures	$840 \times 420$
R ( $\lambda/\Delta\lambda$ )	500-50,000

## POLLUX

UV spectropolarimeter (on LUVOIR-A only)

Point-source UV spectropolarimeter (European study for LUVOIR-A only)

Bandpass	100-400 nm
R ( $\lambda/\Delta\lambda$ )	120,000
Circular + linear polarization	



4-m off-axis monolith primary mirror

Total wavelength range: 115 nm – 1.8  $\mu$ m

Four instruments:

- Coronagraph Instrument → similar to LUVOIR ECLIPS
- HabEx Workhorse Camera (HWC) → similar to LUVOIR HDI
- UV Spectrograph (UVS) → similar to LUVOIR LUMOS
- Starshade Instrument → unique to HabEx

Serviceable

5-year prime mission duration, 10 years of propellant

Also studied 8 other architectures with smaller apertures



# HQ GUIDANCE FOR HABWORLDS

**Build to schedule:** Mission Level 1 Requirement (e.g., planetary mission strategy)

**Evolve technology:**

- Build upon current NASA investments and TRL-9 technology
- JWST segmented optical system + Roman coronagraph

**Next generation rockets:**

- Larger telescope aperture sizes
- Leverage opportunities offered by large fairings to facilitate mass & volume trades

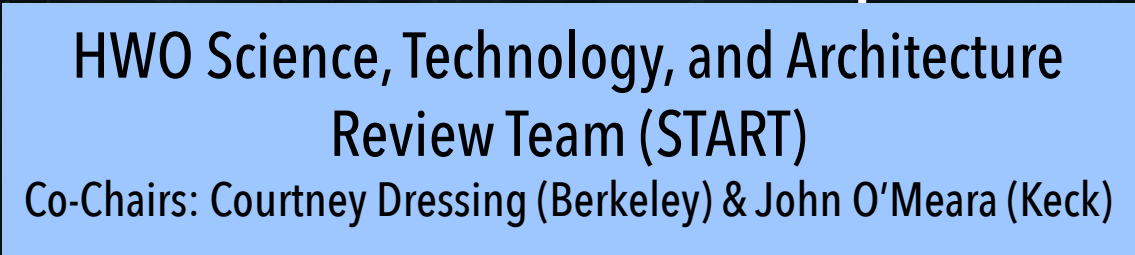
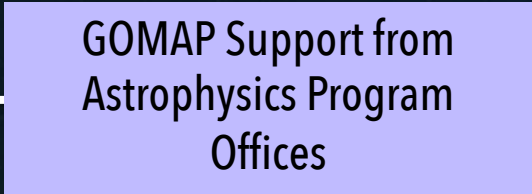
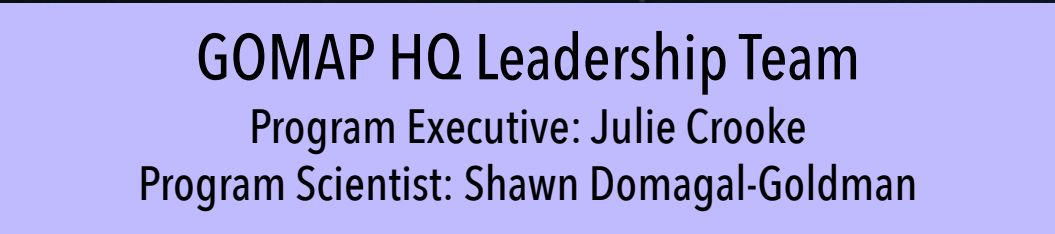
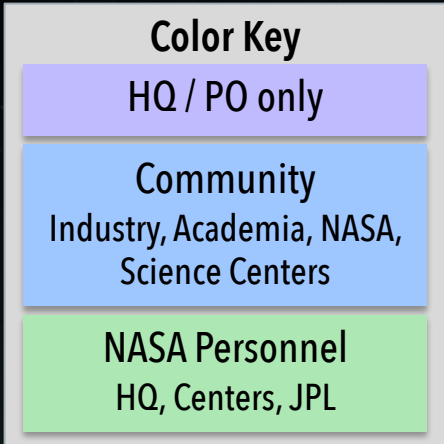
**Planned servicing:** Robotic servicing at L2

**Robust margins:** Design with large scientific, technical, and programmatic margins

**Mature technologies first:** Reduce risk by fully maturing the technologies prior to development phase

Dr. Mark Clampin  
NASA Astrophysics Director  
APAC presentation (slide 33)  
March 29, 2023

# GREAT OBSERVATORY MATURATION PROGRAM (GOMAP)



**Responsibility:** HabWorlds scope

**Objectives:** Goals, objectives, & observations  
Quantify science objectives  
Identify performance breakpoints

**Responsibility:** HabWorlds responsiveness

**Objectives:** Evolved architecture analyses  
Architecture trade deep dives  
Technology development roadmapping

# START MEMBERSHIP

Name	Institution
Charlie Atkinson (ex-officio)	Northrop Grumman
Giada Arney	GSFC
Natasha Batalha	Ames
Eric Burns	LSU
Jessie Christiansen	NExScI
<b>Courtney Dressing (Co-Chair)</b>	<b>UC Berkeley</b>
Matthew East (ex-officio)	L3Harris
Kevin France	CU-Boulder
Scott Gaudi	Ohio State University
Renyu Hu	JPL
Alina Kiessling	JPL
Janice Lee	STScI
Bruce Macintosh	UCO
Eric Mamajek (ex-officio)	ExEP

Name	Institution
Alison Nordt (ex-officio)	Lockheed Martin
<b>John O'Meara (Co-Chair)</b>	<b>W. M. Keck Observatory</b>
Jim Oschmann	retired
Rachel Osten	STScI
Chris Packham	UTSA
Lynnae Quick	GSFC
Swara Ravindranath (ex-officio)	COR
Jason Rhodes	JPL
Jane Rigby	GSFC
Ty Robinson	U of A
Dmitry Savransky	Cornell University
Evan Scannapieco	ASU
Evgenya Shkolnik	ASU
Erik Wilkinson (ex-officio)	Ball Aerospace

# TAG MEMBERSHIP

Name	Institution
Ruslan Belikov	ARC
Matthew Bolcar	GSFC
Jason Derleth (ex-officio)	COR
<b>Lee Feinberg (Eng. Co-Chair)</b>	<b>GSFC</b>
Kevin Fogarty	ARC
Jessica Gaskin	MSFC
Thomas Greene	ARC
Brian Kern	JPL
Marie Levine	JPL
Alice Liu	GSFC
Sangeeta Malhotra	GSFC
Dimitri Mawet	JPL
Michael McElwain	GSFC
<b>Bertrand Mennesson (Sci. Co-Chair)</b>	<b>JPL</b>

Name	Institution
Michael Menzel	GSFC
Patrick Morrissey	JPL
Niki Parenteau	ARC
David Redding	JPL
<b>Aki Roberge (Sci. Co-Chair)</b>	<b>GSFC</b>
Stuart Shaklan	JPL
Nick Siegler (ex-officio)	ExEP
Breann Sitarski	GSFC
Philip Stahl	MSFC
Christopher Stark	GSFC
Julie van Campen	GSFC
Feng Zhao	JPL
<b>John Ziemer (Eng. Co-Chair)</b>	<b>JPL</b>
TBA member - deferred start date	JPL

# NEAR-TERM ACTIVITIES

## START & TAG Kick-Off Meeting

- Oct 31 – Nov 2, 2023
- In-person in DC, with virtual option for public

## HabWorlds Open Splinter Meeting at AAS in New Orleans

- Wed Jan10, 2024

## START-TAG Meeting Agenda

### Tuesday, October 31, 2023 (all times ET)

- 9:00am - 9:05am: Welcome (*Julie Crooke, NASA HQ*)
- 9:05am - 9:20am: Why We Are Here (*John O'Meara, W.M. Keck Observatory*)
- 9:20am - 9:40am: Meeting Goals & Plans (*Courtney Dressing, UC Berkeley*)
- 9:40am - 10:20am: NASA Mission Development 101 (*John Ziemer, JPL*)
- 10:20am - 10:40am: HQ Perspective on HWO & GOMAP (*Mark Clampin, NASA HQ*)
- 11:25am - 11:50am: START & TAG Scope (*Shawn Domagal-Goldman, NASA HQ*)
- 11:50am - 12:15pm: Systems Engineering and the Road to Phase A (*Mike Menzel, GSFC*)
- 1:35pm - 2:00pm: Lessons for the Future: SMD Large Mission Study & LUVOIR (*Aki Roberge, GSFC*)
- 2:00pm - 2:25pm: Lessons for the Future: HabEx (*Bertrand Menesson, JPL & Scott Gaudi, The Ohio State University*)
- 3:25pm - 4:00pm: Breakout Reports & Discussion: Year 1 Goals (*START & TAG*)

### Wednesday, November 1, 2023 (all times ET)

- 9:00am - 9:05am: Welcome Back & Logistics (*Julie Crooke, NASA HQ & Shawn Domagal-Goldman, NASA HQ*)
- 9:05am - 9:55am: Lessons for the Future; JWST (*Lee Feinberg, GSFC & Jane Rigby, GSFC*)
- 9:55am - 10:30am: Lessons for the Future: Roman (*Feng Zhao, JPL & Matt Bolcar, GSFC*)
- 1:50pm - 2:25pm: Lessons for the Future: Industry Panel Featuring *Charlie Atkinson, (Northrop Grumman), Matthew East (L3Harris), Alison Nordt (Lockheed Martin), & Erik Wilkinson (Ball Aerospace)*
- 2:25pm - 3:00pm: Connecting with the NASA Program Offices (*Swara Ravindranath, Eric Mamajek, Jason Derleth, & Nick Siegler*)
- 4:15pm - 5:00pm: Breakout Reports & Discussion: Plans & Working Groups (*START & TAG*)

### Thursday November 2, 2023 (all times ET)

- 9:00am - 9:05am: Welcome Back & Logistics (*Julie Crooke, NASA HQ & Shawn Domagal-Goldman, NASA HQ*)
- 9:05am - 9:25am: Mentorship Program and Workforce Development Workshop (*Courtney Dressing, UC Berkeley & Julie Crooke, NASA HQ*)
- 10:40am - 11:10am: Communications & Outreach Planning (*Shawn Domagal-Goldman, NASA HQ & Alise Fischer, NASA HQ*)
- 1:45pm - 2:30pm: Breakout Reports & Discussion: Mentorship & Outreach (*START & TAG*)
- 2:30pm - 3:00pm: Meeting Wrap: Deliverables, Actions, & Next Steps (*Julie Crooke, NASA HQ & Shawn Domagal-Goldman, NASA HQ*)

### WebEx Meeting Connection Information

<https://nasaenterprise.webex.com/nasaenterprise/j.php?MTID=m555da0886a65f8b41ff00b9ffe8b2d70>

Meeting number: 2763 836 0009

Password: nressHD23! (67377432 from phones and video systems)



# WORKING GROUPS

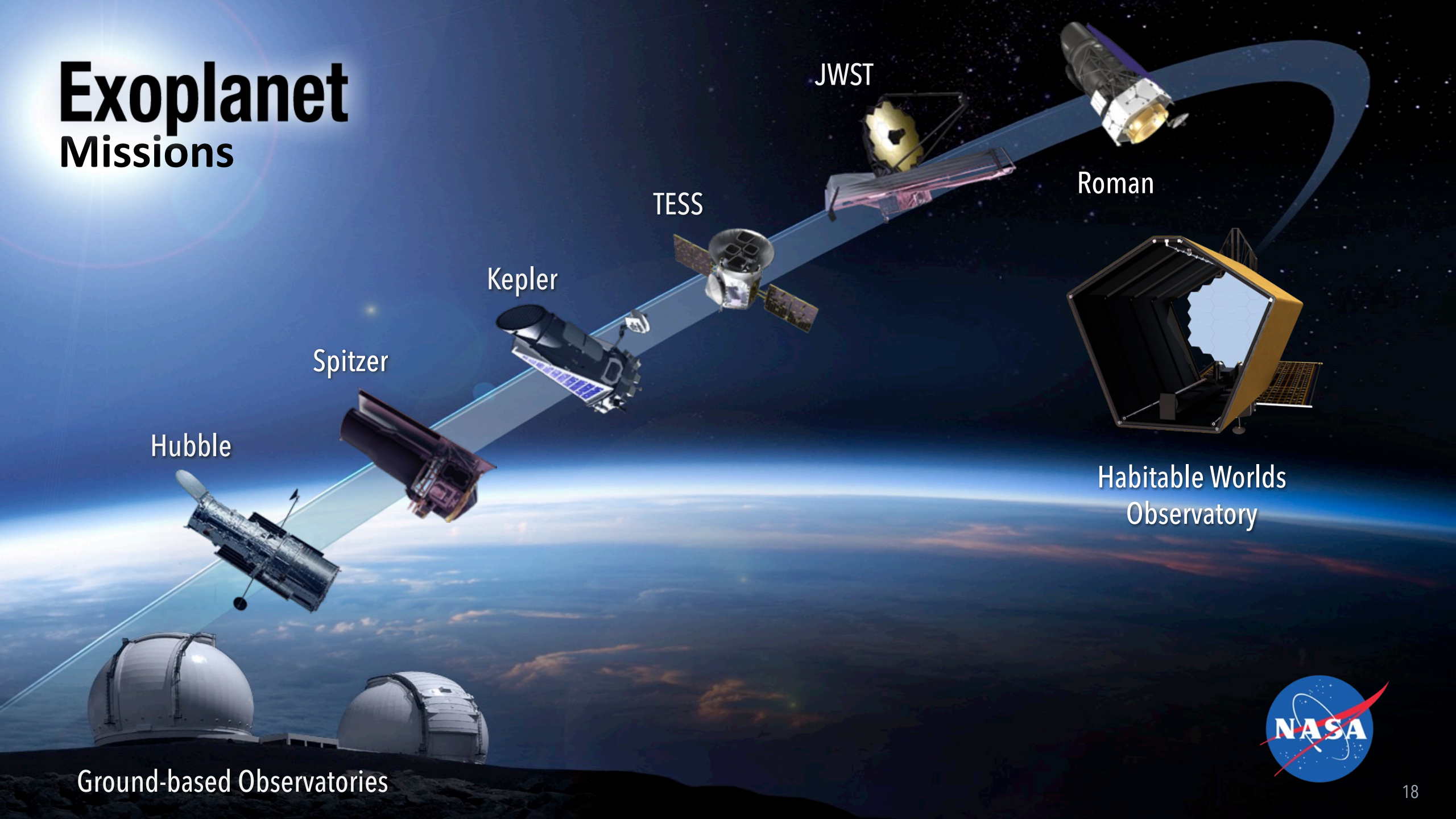
The START & TAG need more help & expertise to get all tasks done ...

... And we want to broaden participation in HabWorlds

We will be forming Working Groups over the next months

- Participants from US and non-US institutions welcome (with restrictions on ITAR material)
- Information about Working Group topics and how to join will be presented at the HabWorlds Splinter Meeting in Jan

# Exoplanet Missions



JWST

Roman

TESS

Kepler

Spitzer

Hubble

Habitable Worlds  
Observatory

Ground-based Observatories

