SIG #1: Toward a 5-10 Year Plan for Exoplanets.

ExoPAG 10 Meeting

Boston, MA

June 6, 2014

Scott Gaudi (Chair)

Goal.

To develop a holistic*, broad, unified, and coherent plan for exoplanets for the next 5-10 years, with community consensus, focusing on areas where NASA can contribute.

* ho·lis·tic *adjective* \hō-'lis-tik\

: relating to or concerned with complete systems rather than with individual parts

SIG #1: Charter.

The goal of this Science Interest Group is to begin the process of developing a holistic, broad, unified, and coherent plan for exoplanet exploration, focusing on areas where NASA can contribute. To accomplish this goal, the SIG will work with the ExoPAG to collect community input on the objectives and priorities for the study of exoplanets. Using this input, it will attempt develop a near term (5-10 year) plan for exoplanets, based on the broadest possible community consensus. The results of this effort will serve as input to more formal strategic planning activities that we expect will be initiated after the mid-decadal review, in advance of the next decadal survey.

Motivation.

- Thesis: A community consensus going into the mid-decadal review, and particularly the next decadal survey, will improve the chances that our priorities will be executed and/or highly ranked.
- Auxilliary: a community consensus will facilitate coordinated efforts to attract other sources of support (industry, philanthropy, entertainment, international).

Brainstorming.

- Why?
  - What are the big questions/inquiry areas in exoplanets?
- What?
  - What measurements do we need to make to answer these questions?
- How?
  - What telescopes/"instruments"/missions/ technology do we need to make these measurements?

Inquiry Areas.
(Why?)

- .

- ??

Inquiry Areas.
(Why?)

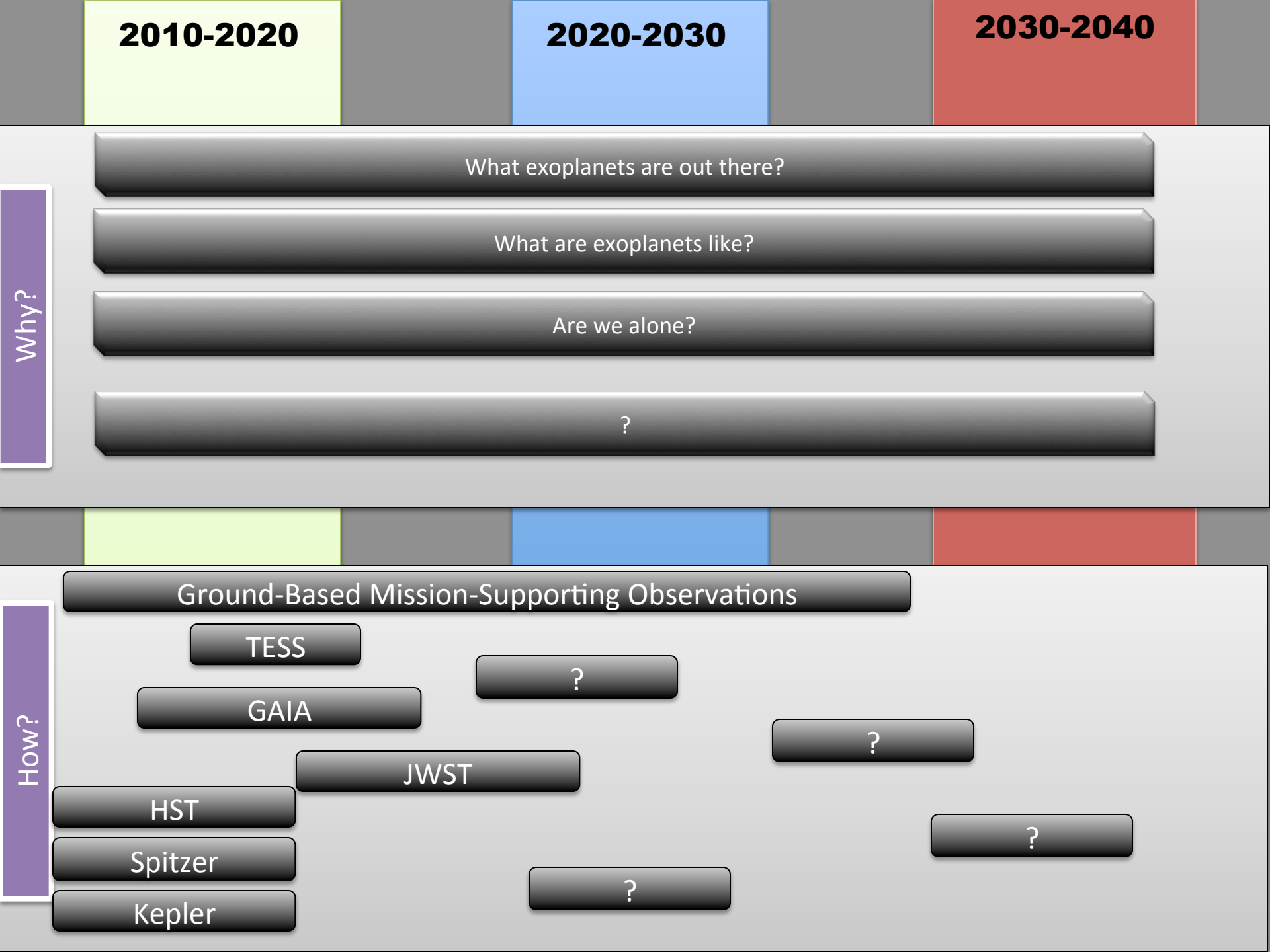
- What exoplanets are out there?
  - Formation and Evolution of Planets
- What are exoplanets like?
  - Atmospheres and Interiors of Planets
- Are we alone?
  - Requirements, Frequency and Evolution of Habitability and Life
- ??

Measurements (What?).

- Demographic measurements (surveys)
  - RV, transits, microlensing, direct imaging, ?
- Characterization methods (follow-up).
  - Transiting planets, directly-imaged planets
- ?

How?

- Ground-based Observations
  - …
- Space-based Missions
  - Now
    - Kepler/HST/Spitzer
  - Soon
    - GAIA/CHEOPS/TESS
  - Possible future
    - WFIRST (?), PLATO (?)
  - Future?


2010-2020
2020-2030
2030-2040
Why?
What exoplanets are out there?
What are exoplanets like?
Are we alone?
?
How?
Ground-Based Mission-Supporting Observations
TESS
?
GAIA
?
JWST
HST
?
Spitzer
?
Kepler

Why/What/How Matrix

		RV	HST	Spitzer	Kepler	Gaia	TESS	JWST	?	?	?	?	?	?
What is the frequency and diversity of plantary systems? (Demographics)	Obtain a complete statistical census of planets in the Galaxy.				X	X								
	Survey the closest planetary systems.	X				X	X							
	(Measure the frequency of potentially habitable planets)	X			X									
What are the natures of planetary interiors, surfaces, and atmospheres?	Characterize a diverse set of planetary atmospheres.		X	X				X						
	Characterize exoplanets orbiting the closest stars.		X	X				X						
	(Understand the interiors, surfaces, and atmospheres of Earthlike exoplanets.)							X						
Is there life on other planets?	Measure the frequency of potentially habitable planets.	X			X									
	Understand the interior, surfaces, and atmospheres of Earthlike exoplanets.							X						X
	Find nearby potentially habitable planets.	X					X							
	Discover habitable climates on nearby planets.	X						X						
	Search for surface and atmospheric biomarkers.													

Also How/Technology Matrix

Next Steps.

- Community input.
  - Telecons, private discussions.
  - Exoplan Workshop (Fall 2014)
- Synthesis
  - List of important questions (Early 2015)
  - Skeleton outline (Late 2015)
- Report delivered to subsequent roadmapping committees (early 2016)

We need your help!

Rus Belikov

Avi Mandell

Karl Stapelfledt Gary Copeland

Jim Kasting

Lisa Kaltenegger

Margaret Turnbull

Evgenya Shkolnik

Josh Pepper

Marshall Perrin

Supriya Chakrabarti

Angelle Tanner Brian Jackson

Valeri Makarov

James Breckinridge

Eugene Serabyn

Daniel Apai

Aki Roberge

Ron Polidan

Daniel Apai

Steve Unwin

Wes Traub

Jill Tarter

Tom Greene

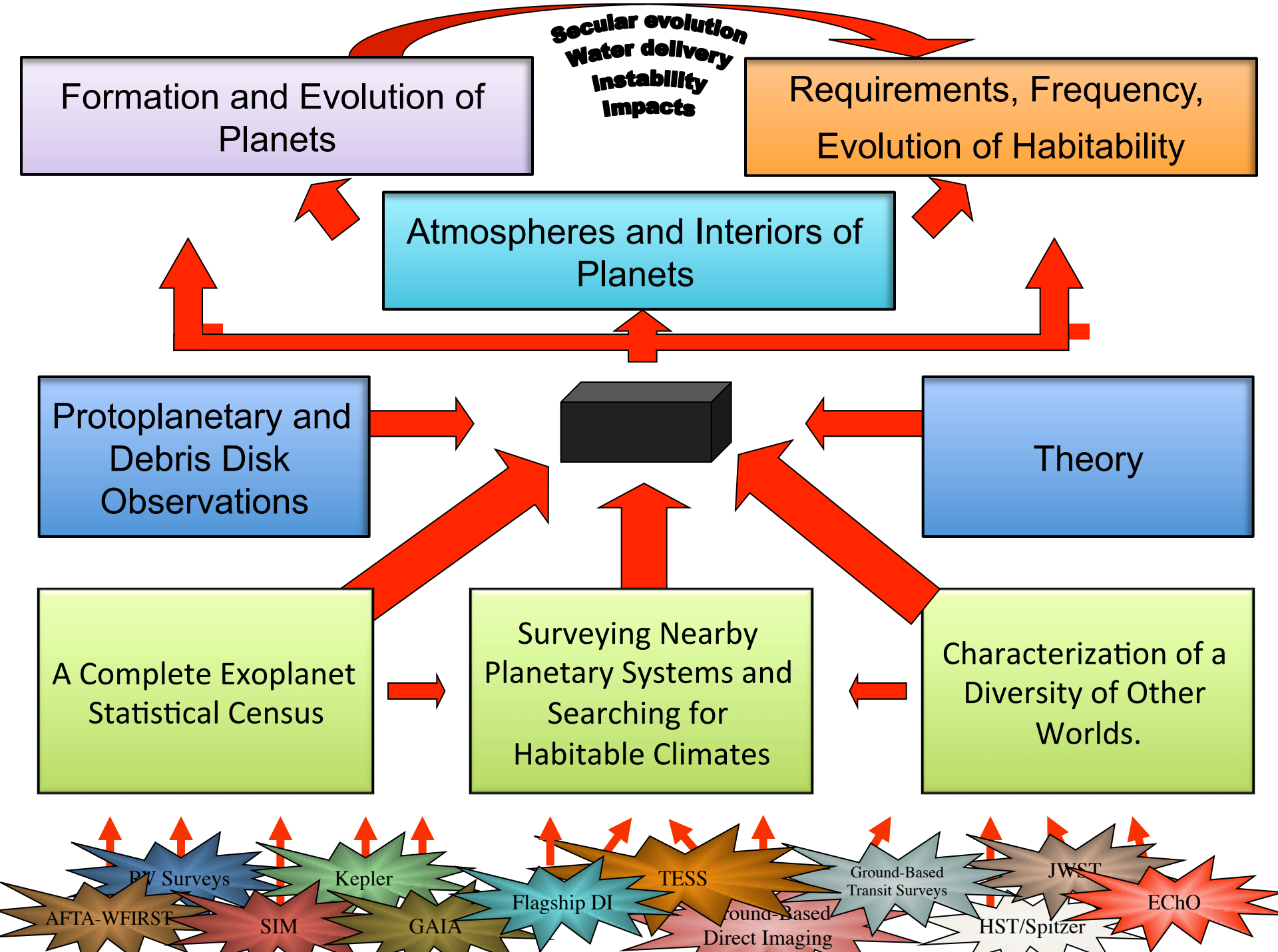
Jeff Linsky

You!

Back-up Slides.

Goals.

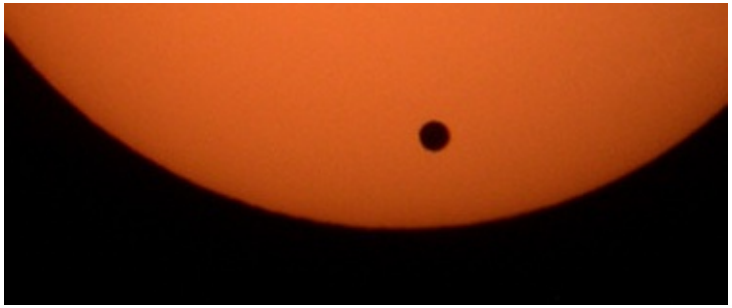
- A Complete Exoplanet (Statistical) Census.
- Characterization of a Diversity of Other Worlds.
- Surveying Nearby Planetary System and Searching for Habitable Climates.


Secular evolution
Water delivery
Instability
Impacts
Formation and Evolution of Planets
Requirements, Frequency, Evolution of Habitability
Atmospheres and Interiors of Planets
Protoplanetary and Debris Disk Observations
Theory
A Complete Exoplanet Statistical Census
Surveying Nearby Planetary Systems and Searching for Habitable Climates
Characterization of a Diversity of Other Worlds.
RV Surveys
Kepler
TESS
Ground-Based Transit Surveys
JWST
AFTA-WFIRST
SIM
GAIA
Flagship DI
Ground-Based Direct Imaging
HST/Spitzer
ECHO

Habitable Planets.

	High Mass (>0.5M_{Sun}) ★s		Low Mass (<0.5M_{Sun}) ★s	
	Frequency	Habitability	Frequency	Habitability
Current	Kepler	-	RV MEarth	-
Future	RV? WFIRST-AFTA?	RV? Astrometry? ↓ ? Direct Imaging Mission	TESS PLATO?	MEarth TESS PLATO? ↓ JWST NGELTs?

"Pale Blue Dot"



"Small Black Shadow"

WFIRST+C Discussion at ExoPAG 7.

- Scheduled talk from David Spergel on AFTA, but…
- Brief summary of AFTA SDT activities up to that point.
- Group discussion:
  - Does the community endorse putting a coronagraph on AFTA/ WFIRST, even if it means forgoing some future technology development opportunities and/or other small-scale direct imaging missions?*
- Unanimous yes!
- This was considered an important endorsement by NASA.

Hasn't this been done many many times?

- Yes.
  - Exoplanet Task Force (chaired by J. Lunine)
  - Exoplanet Community Report (Lawson, Traub & Unwin)
  - NASA 30-Year Roadmap (chaired by C. Kouveliotou)
- A lot of the hard work has been done, lots of idea out there.
- In the past, were these effective? If no, why not?

How is this different than the recent NASA Roadmap?

- Different goal: Inspire continued funding of astrophysics at the current (JWST) level.
- Much longer term, 30-40 years out.
- Unencumbered by funding considerations.
- Generally focused on notional, large-scale, visionary mission concepts.
- We need something more specific, concrete, and short term.

Some Open Questions.

- Do we need additional capabilities for characterization of exoplanets?
- How do we measure the masses of the nearby habitable planets?
- What are the future roles of astrometry and interferometry?
- How do we achieve a consensus plan, particularly for the F-DIM, in time for the next decadal review?
  - Starshade versus coronograph.
  - If coronagraph: what architecture?
- Others?