

Toward a 5-10 Year Plan for Exoplanets.

ExoPAG 9 Meeting
Washington, DC
January 4+5, 2014
Scott Gaudi

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.

Why?

- 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).

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)
- Hard work has largely been done.
- 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.

Initial Discussion at ExoPAG 8.

- Reaction largely positive.
 - But: relatively low attendance.
- On that basis, approached APS for their blessing:
 - Was some concern that this would override or preempt future, more formal activities.
 - Was some concern that this may lead to resources being taken away from other fields.
 - Suggested that we return to the community to see if there is interest in this activity.
 - If so we can formalize this as a “Science Interest Group (SIG)”

Science of Exoplanets.

- Pale Blue Dots vs. Exoplanet Astrophysics.
- Finding and characterizing a ‘pale blue dot’ remains a long-term goal.
- But there are many other exoplanet science questions that we can and should address in the interim.
- Many of these will likely bear directly on our understanding of habitable worlds – these are not disparate goals!
- Let’s take a step back: what are the ‘big’ science questions in exoplanets?

Inquiry Areas.

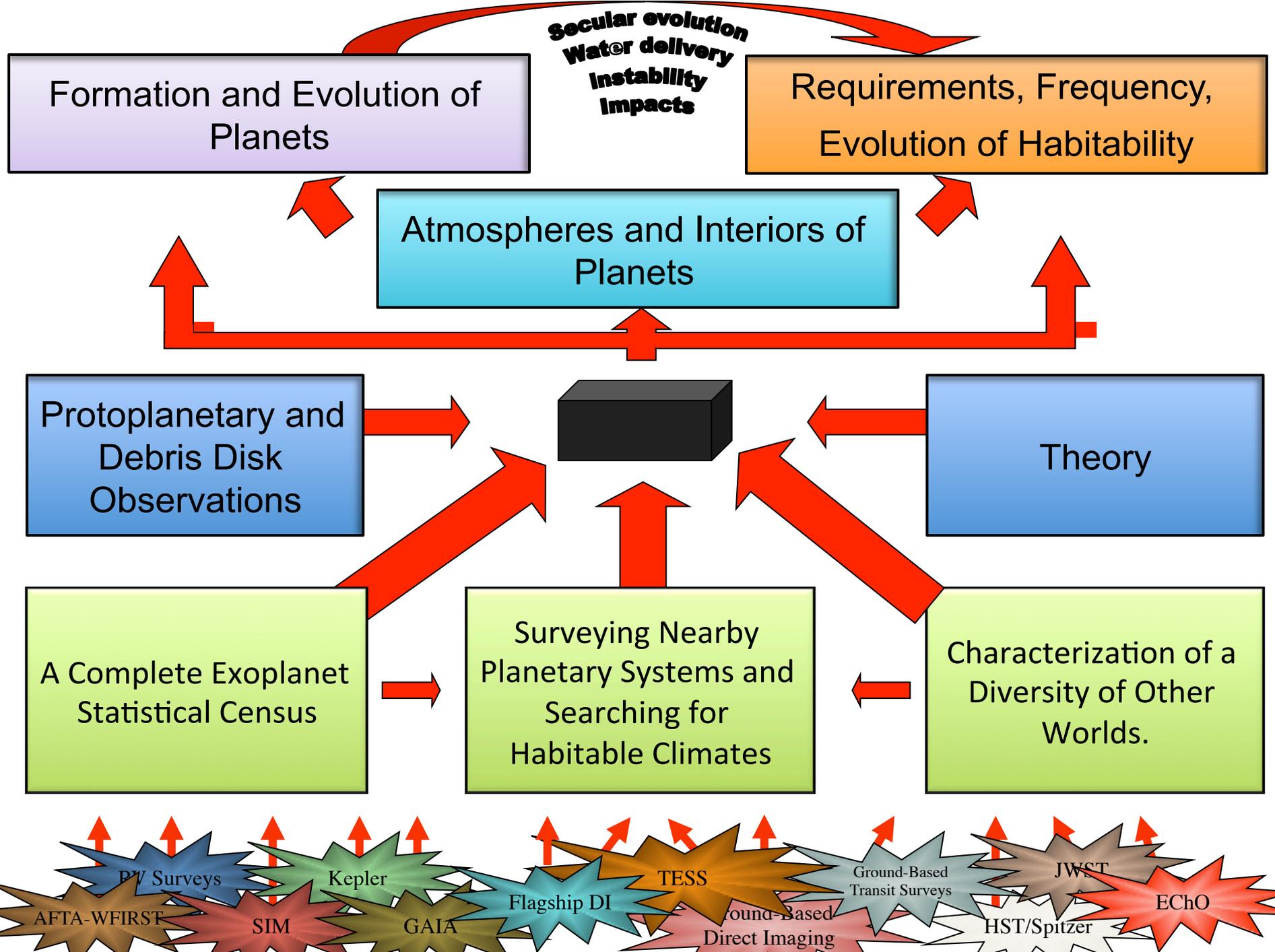
- Formation and Evolution of Planets.
- Atmospheres and Interiors of Planets.
- Requirements, Frequency and Evolution of Habitability.

Tools.

- Demographics.
- Characterization.
- Census and characterization of nearby systems.

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.

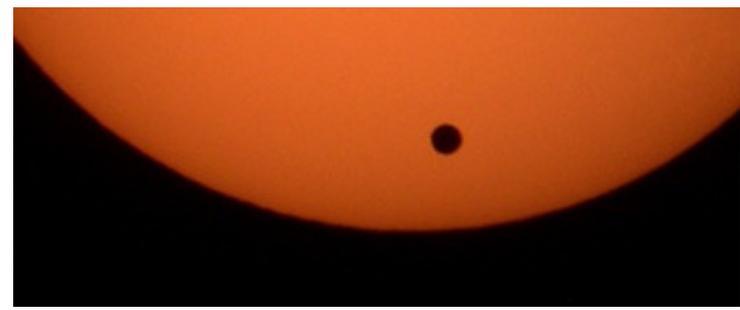
AFTA-WFIRST, PV Surveys, SIM, Kepler, GAIA, Flagship DI, TESS, Ground-Based Direct Imaging, Ground-Based Transit Surveys, HST/Spitzer, JWST, EChO

Habitable Planets.

	High Mass ($>0.5M_{\text{Sun}}$) ★s		Low Mass ($<0.5M_{\text{Sun}}$) ★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”

2010-2020

2020-2030

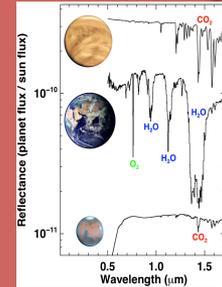
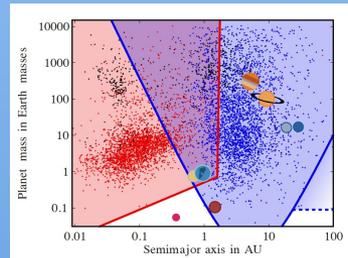
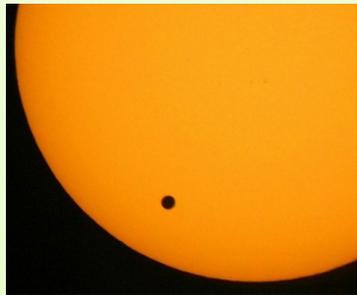
2030-2040

Science Roadmap

A Complete Exoplanet Census

Characterization of a Diversity of Other Worlds

Our Nearest Neighbors:
Surveying Nearby Planetary Systems and Searching for Habitable Climates



Mission Roadmap

Ground-Based Mission-Supporting Observations

TESS

JWST

HST

WFIRST+C

F-DIM:
(Flagship Direct
Imaging Mission)

Spitzer

Transit Char.
Mission?

Astrometry
Mission?

Kepler

Mission Matrix, e.g.

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

Technology, other support.

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 coronagraph.
 - If coronagraph: what architecture?
- Others?