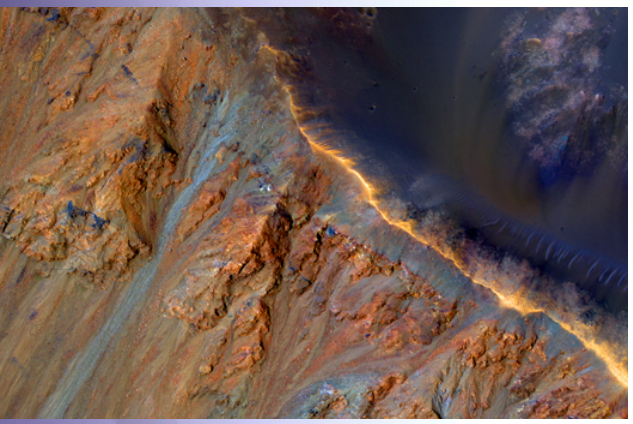
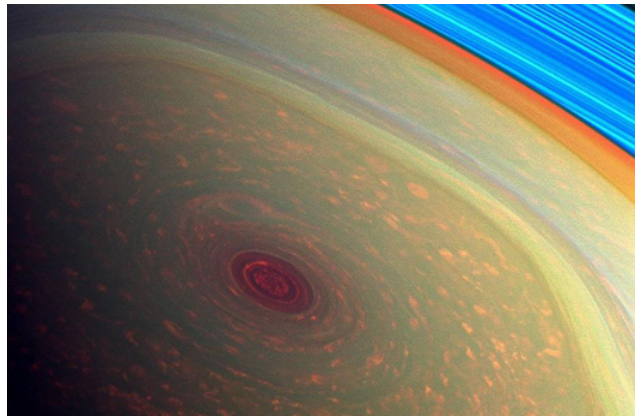
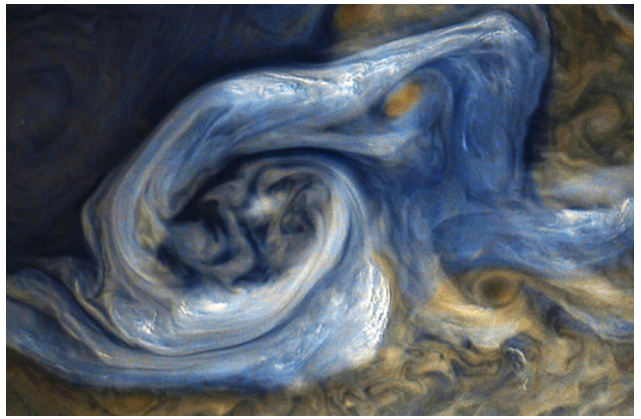
SCIENCE

National Aeronautics and Space Administration

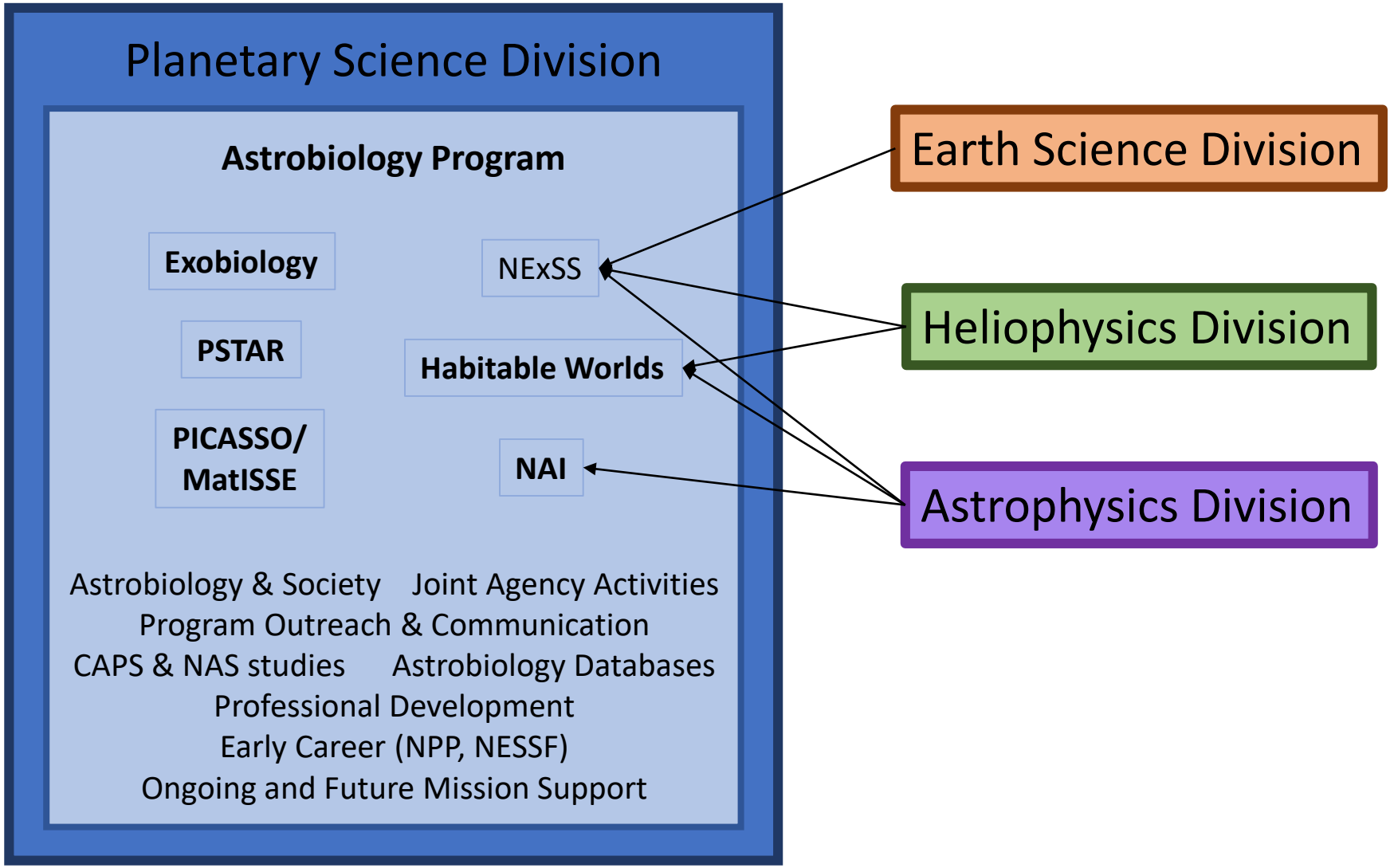

Astrobiology Update

Mary Voytek

Senior Scientist Astrobiology
Planetary Science Division

March 27, 2018

ABP Organization



Dr. Lindsay Hays

Scientific background in Organic Geochemistry

- PhD in Geobiology from MIT, postdoc at Harvard – lipid biomarkers for major transitions in Earth's Biosphere

NASA HQ – NPMP Astrobiology Program

- Astrobiology Strategy
- Early Evolution of the Earth Workshop

JPL – Mars Program Office, Mars Sample Return Science System Engineer

- Mars Sample Return
- Humans to Mars

IPA at HQ from JPL serving as Deputy Program Scientist for the Astrobiology Program

C.5 EXOBIOLOGY

NOTICE: This program element no longer uses the two-step proposal submission process common in Appendix C. Instead, a Notice of Intent (NOI) is requested in place of a Step-1 proposal.

2.2 Program Exclusions

- Research aimed at investigating the habitability of planetary bodies in our Solar System other than Earth or in other planetary systems should be submitted to the Habitable Worlds program (E.4).
- Proposals focused on the formation and stability of habitable planets and the formation of complex organic molecules in space and their delivery to planetary surfaces should be submitted to the Emerging Worlds program (C.2).
- Proposals aimed at the identification and characterization of radio signals from
- extrasolar planets that may harbor intelligent life are not solicited at this time.

2.11 Antarctica

- The Exobiology Program is no longer accepting proposals for work in Antarctica.

C.14 Planetary Science and Technology Through Analog Research

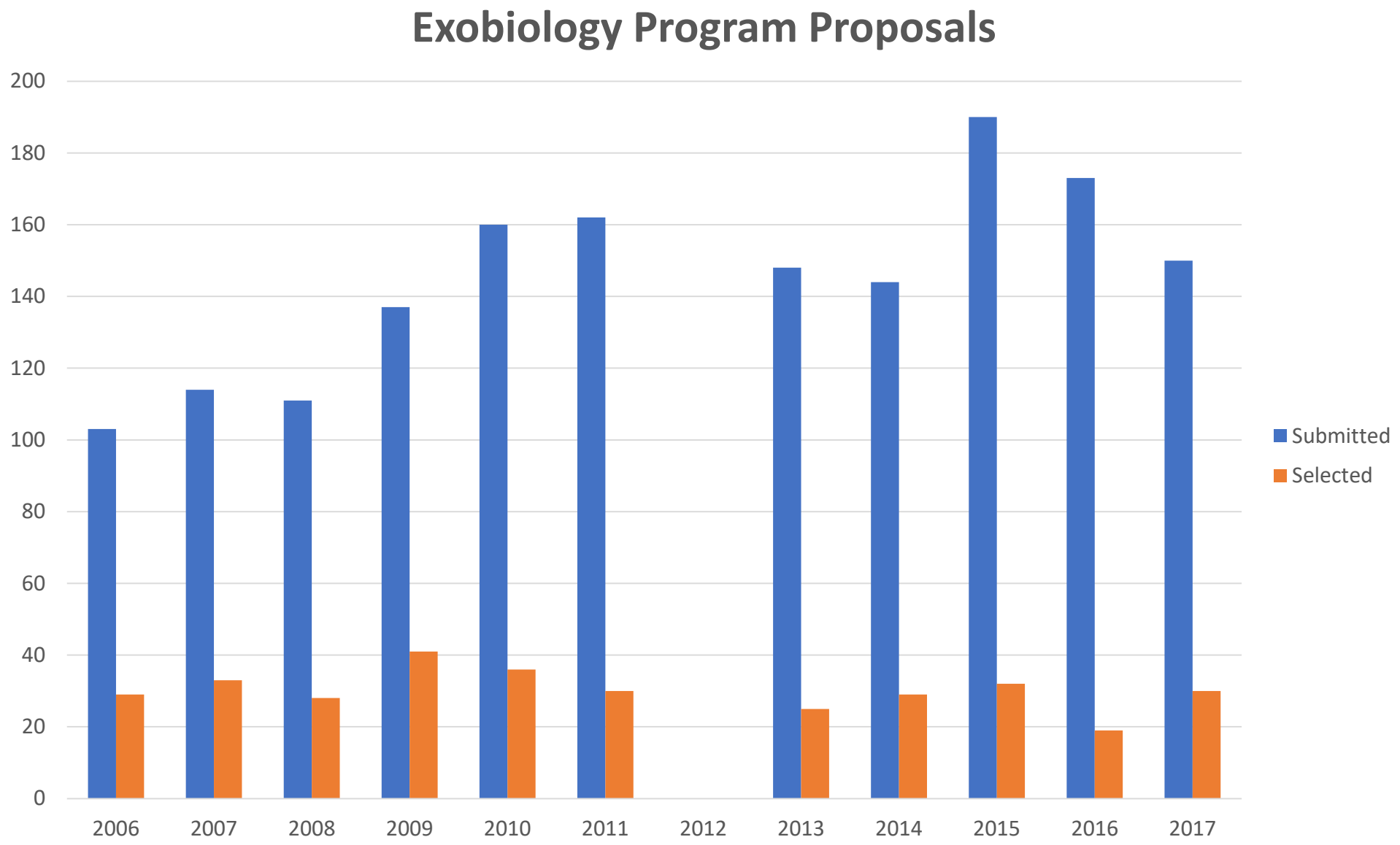
3.2 Restriction on Funding for Mission-Related Activities

- Unless otherwise specified in the program element, proposals containing work for a mission team member, or for a worker who will directly collaborate with a mission team, may not request funding that is intended to help the mission meet its science requirements or achieve mission success. These proposals may also not request funding for work that is close in scope to a mission's funded activities.
- This restriction applies regardless of the mission team-member's or collaborator's role on the proposal (e.g., PI, Co-I, collaborator, postdoc, student) or role on the mission. It applies when the mission is in phases A through F, unless otherwise specified in the program element.
- If a proposal includes workers on, or collaborating with, a mission team and contains work that is relevant to that mission, it must demonstrate how the tasks to be funded by the proposal do not violate this restriction. This demonstration should be included in the proposal's Budget Justification section and does not count against the page limit of the Scientific/Technical/Management section.

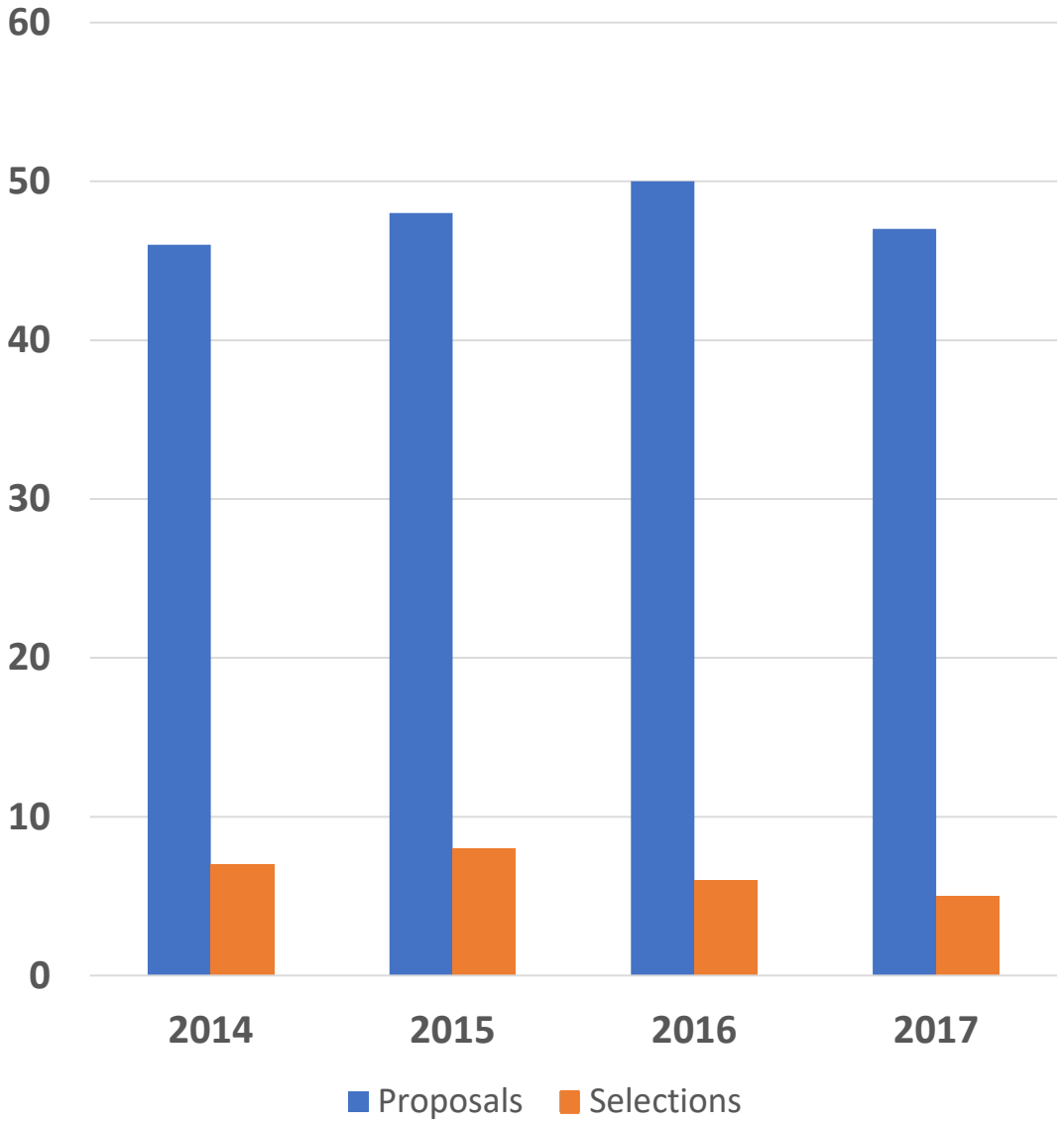
E.4 Habitable Worlds

- NASA's Habitable Worlds Program includes elements of the Astrobiology Program, the Mars Exploration Program, the Outer Planets Program (all in the Planetary Science Division), Exoplanet research in the **Astrophysics Division**, and Living With a Star in the **Heliophysics Division**.

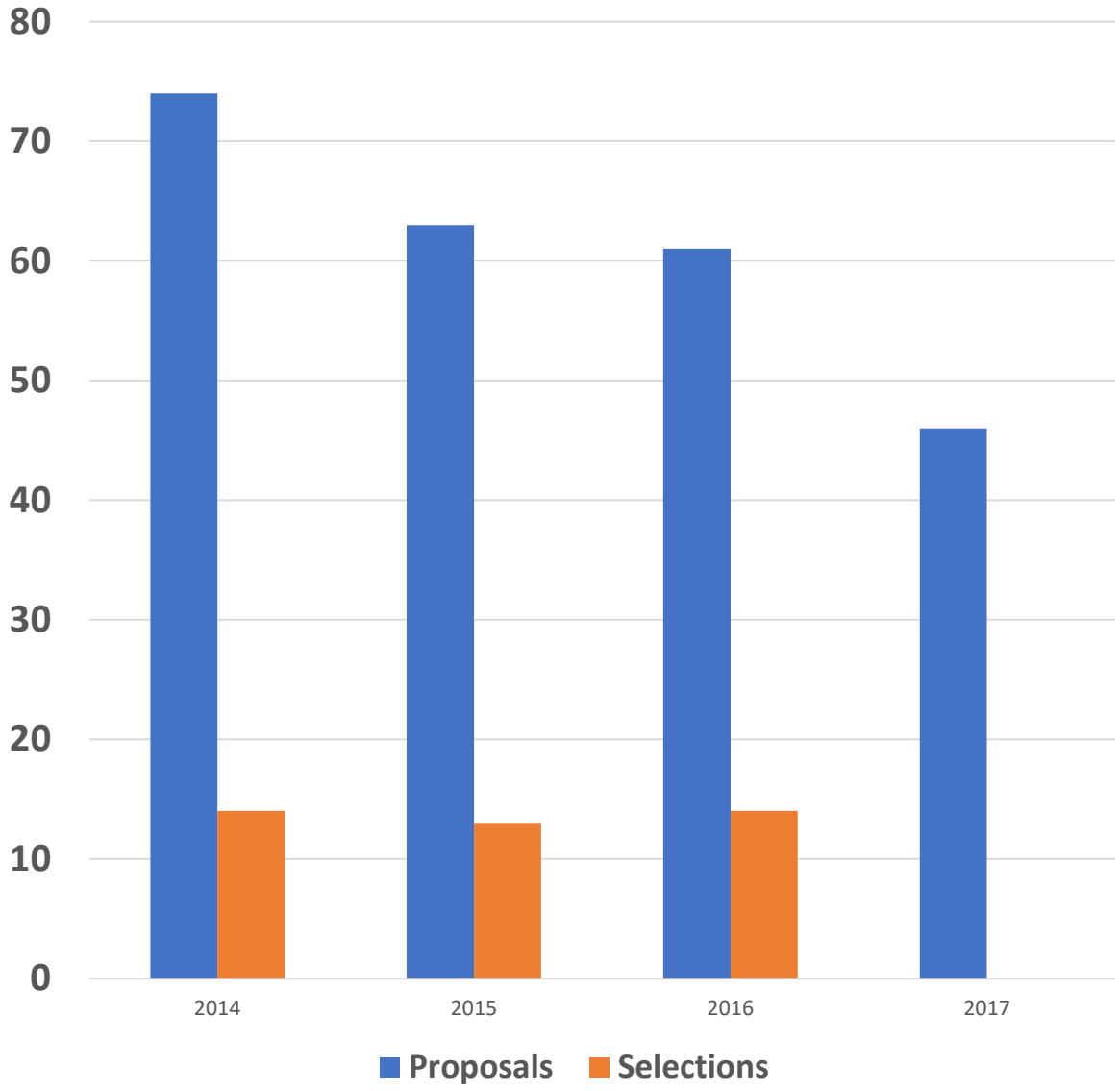
• Mars - the astrobiological potential of past or present environments on or in the Martian surface or subsurface.
• Icy Worlds - the astrobiological potential of icy worlds in the outer solar system, including Europa, Ganymede, Enceladus, and Titan.
• Habitable Exoplanets and/or their moons - A potentially habitable exoplanet implies a planet with conditions roughly comparable to those of Earth (i.e., an Earth analog) and thus potentially favorable to the presence of life.


Exobiology Program Proposals
200
180
160
140
120
100
80
60
40
20
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Submitted
Selected

PSTAR Program Proposals



Habitable Worlds Program Proposals

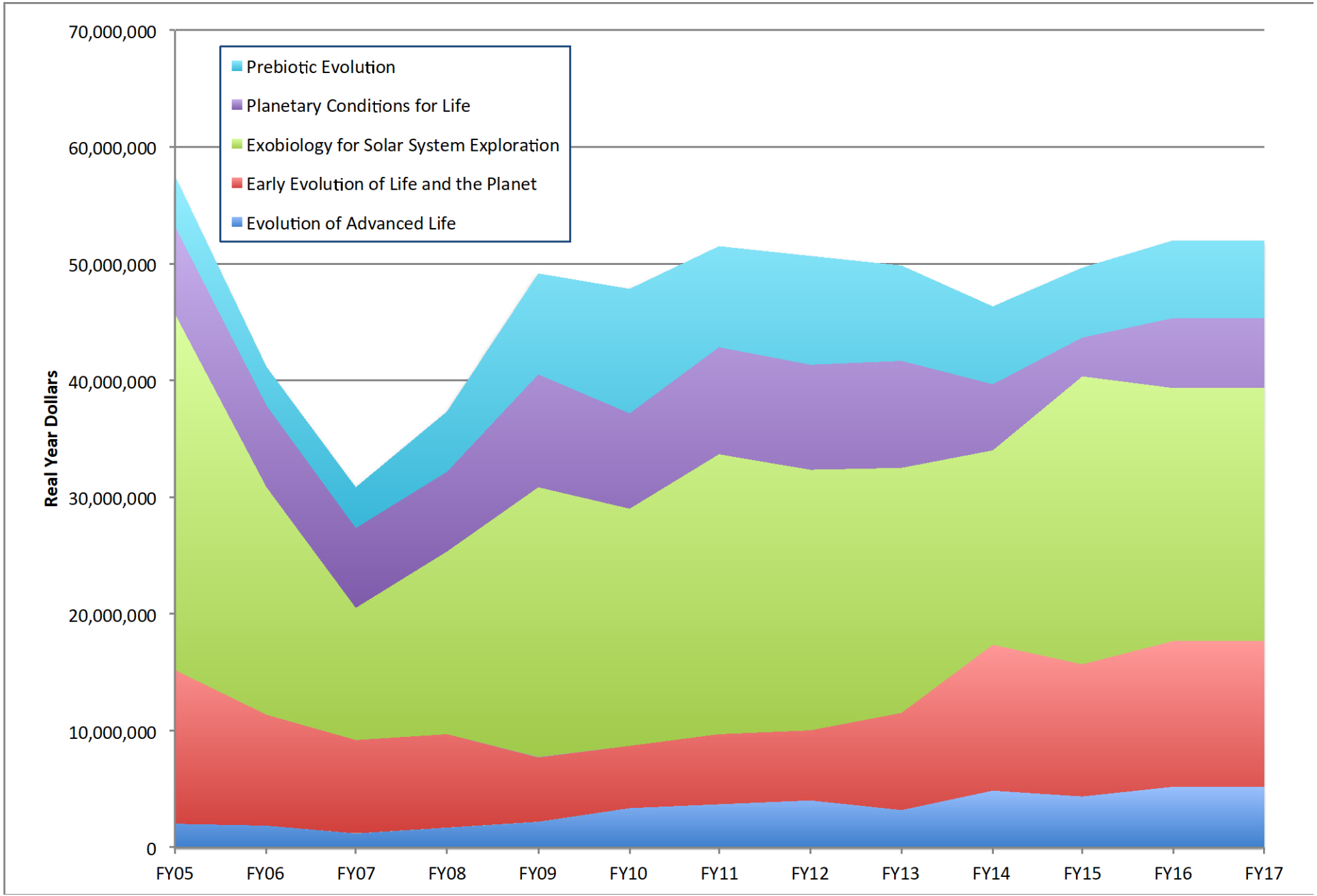


Cooperative Agreement Notice for the NASA Astrobiology Institute

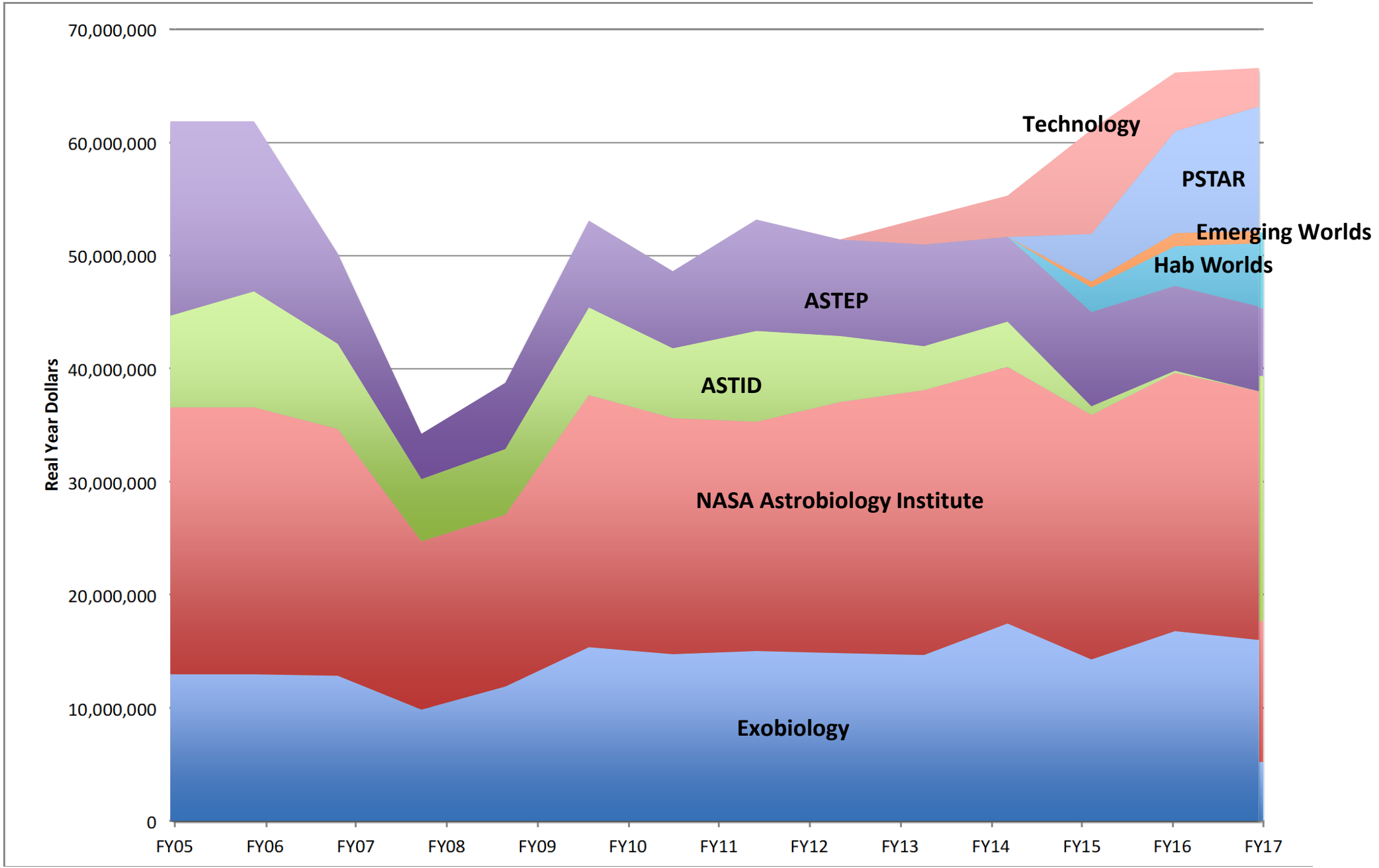
The time line for the CAN 8:

Release of CAN…… February 2017
Proposals Due……..July 2017
Selection of CAN 8 teams……January 2018
Start of new awards……..April 2018

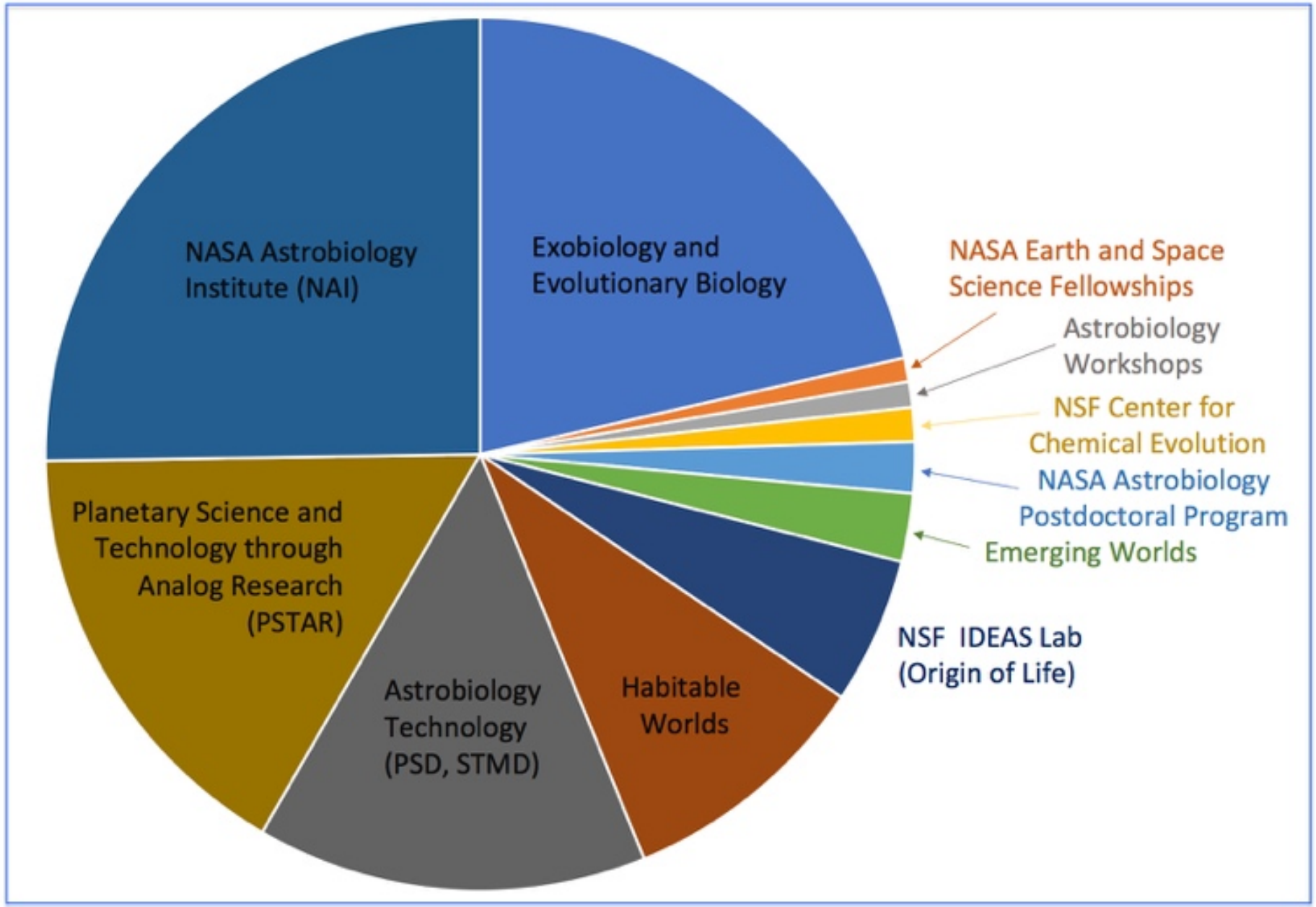
Astrobiology Research Area Portfolio



Astrobiology Funding by Program



Typical annual allocations of astrobiology funds support basic research, technology, and development for off-world exploration.



What's the best way to manage interdisciplinary, cross-cutting research?

- NASA helped to create Planetary Science (1960s) and Earth Systems Science (1970s) and as they matured created HQ organizations to manage missions in these areas.
- Astrobiology (1990s) was created by NASA. NASA created a *virtual institute* (VI) to encourage and sustain research in it.
  - Model has been adopted across the agency.
- Exoplanet research is a new, interdisciplinary field that involves the expertise of four of SMD's divisions. How best to encourage and sustain it?
- NExSS is an experimental *Research Coordination Network (RCN)* aimed at encouraging and sustaining interdisciplinary, cross-cutting research.

What is a Research Coordination Network?

A *Research Coordination Network (RCN)* is a virtual structure to support groups of investigators to communicate and coordinate their research, training and educational activities across disciplinary, organizational, divisional, and geographic boundaries.

What is NExSS?

- A research coordination network dedicated to the study of planetary habitability and the search for life on exoplanets.

- A NASA cross-division initiative bringing astrophysicists, planetary scientists, Earth scientists, and heliophysicists together to explore the potential of “systems science” thinking* in exoplanet research.

- *Not tied to any single observational strategy.

Scientific goals of NExSS

- Investigate the diversity of planets
- Understand how planet history, geology, and climate interact to create the conditions for life
- Put planets into an architectural context as stellar systems built over time by dynamical processes and sculpted by stars
- Use experience from solar system (including Earth) history to identify where habitable niches are most likely to occur and which planets are most likely to be habitable
- Leverage NASA investments in research and missions to accelerate discovery and characterization of potential life-bearing worlds

Objectives of NExSS

- To further our joint strategic objective to explore exoplanets as potentially habitable and inhabited worlds outside our solar system.
- To establish common goals across SMD divisions; Planetary Science (PSD), Heliophysics (HPD), Earth Science (ESD) and Astrophysics (APD).
- To leverage existing Programs in SMD to advance the field of exoplanet research, specifically research in comparative planetology, biosignature and habitat detection, star-planet interactions, and planet characterization.
- To establish a mechanism to break down the barriers between divisions, disciplines, and stove-piped research activities.

Establish Measures of success of NExSS

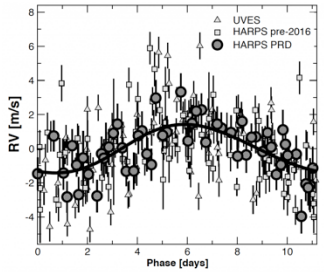
- Investigators carry out and propose interdisciplinary research through new collaborations
- Produces a plan for utilization of current space telescopes
- Spawns ideas for new and exciting missions
- Identifies new targeted technologies needed not yet reported elsewhere
- Influences Decadal Surveys for both Planetary Science and Astronomy and Astrophysics
- Enhances international engagement

The NExSS Teams

D. Fischer
A. Jensen
J. Graham

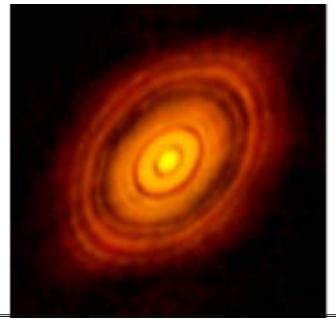
Exoplanet Detection

E. Ford
D. Deming
J. Wright



Exoplanet Characterization

N. Turner
H. Jang-Condell
D. Apai

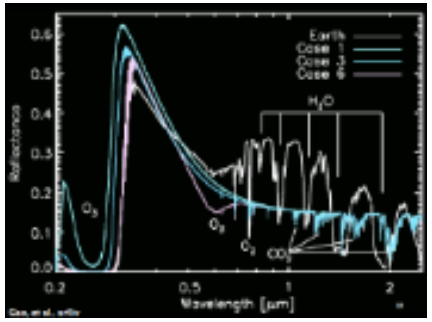


Disks & Planet Formation

<u>HQ reps:</u>
Mary Voytek (PSD)
Doug Hudgins (ASD)
Jared Leisner (HSD)
Shawn Domagal-Goldman

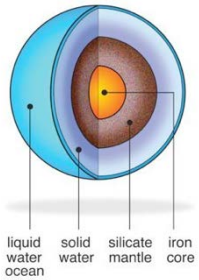
<u>Co-leads:</u>
Natalie Batalha
Dawn Gelino
Tony Del Genio

Management



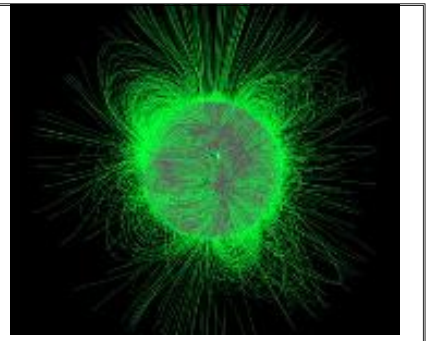
H. Imanaka

Laboratory Astrophysics



W. Henning
J. Fortney

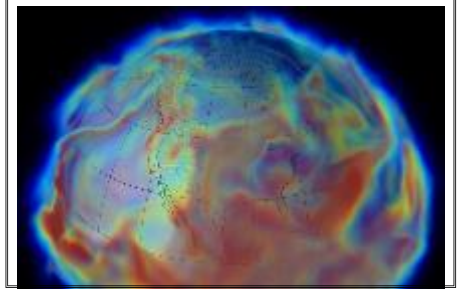
Planetary Structure and Evolution



V. Airapetian
B. Moore
D. Brain

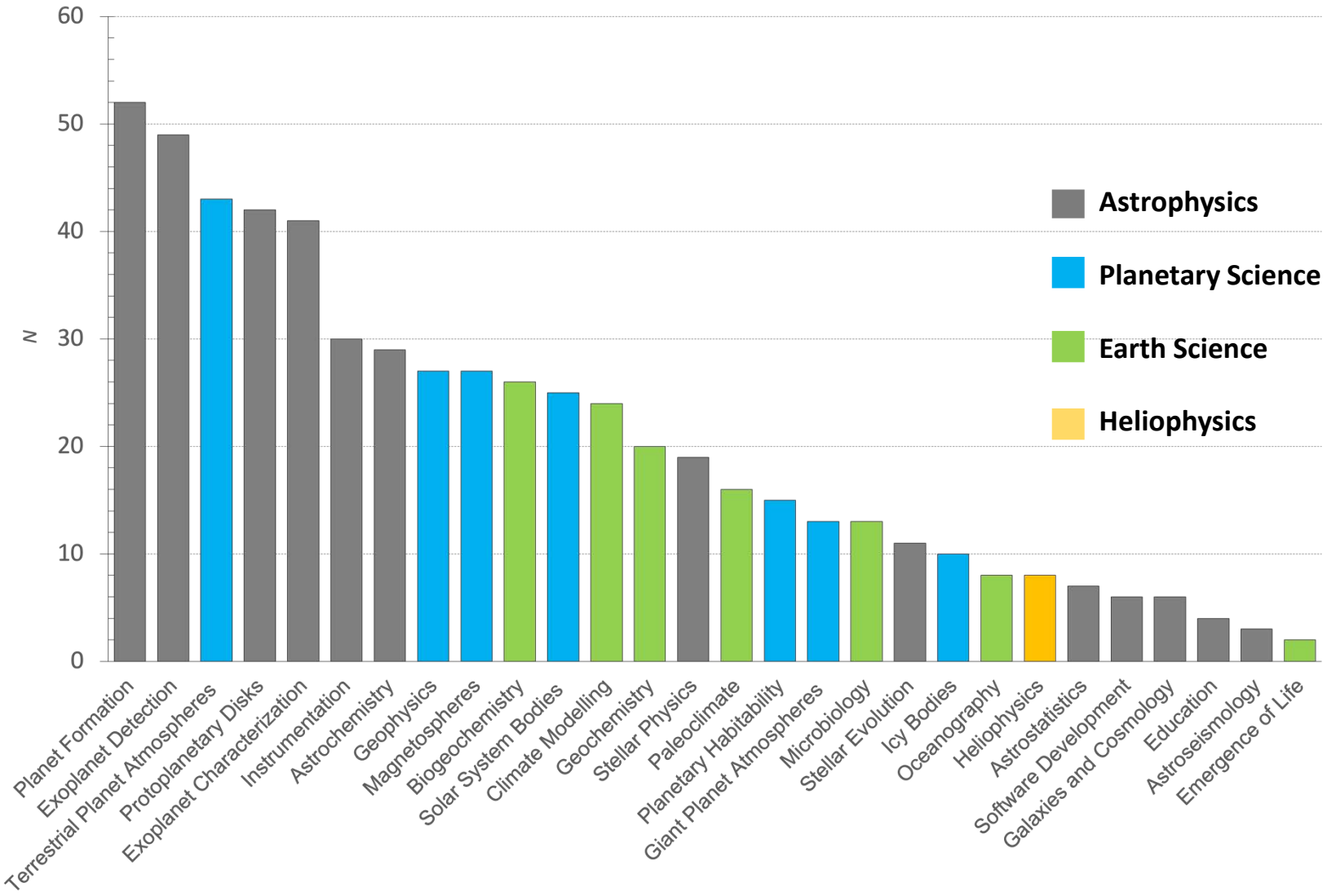
Space Weather

S. Desch
V. Meadows
T. Del Genio



Planetary Habitability and Detectability

Diversity of researchers in NExSS



NExSS Measures of Success (1)

The NExSS leadership is conducting a self-assessment based on NSF evaluation metrics.

- **Investigators carry out and propose interdisciplinary research through new collaborations**
  - Exo-Mineralogy: a new “discipline” arose as a result of a workshop between astronomers and solid earth scientists.
  - Habitable Worlds always had received exoplanet proposals but there an uptick in exoplanet proposals from PIs that had never proposed to Exobiology or the NAI.
  - Several proposals from NExSS PIs, Co-Is, and collaborators submitted to Exoplanet Research Program and Topical Workshops Program. One grant awarded to two new, collaborating researchers that developed the idea for the proposal at the “Upstairs Downstairs” Winter school.
- **Produces a plan for utilization of current space telescopes**
  - JWST Early Release Science working group lead NExSS. Two proposals submitted by NExSS PIs and their collaborators won 23% of the allotted ERS time.

NExSS Measures of Success (2)

- **Spawns ideas for new and exciting missions**
  - STDT Leadership and significant participation in LUVOIR and HabEx mission concept studies by NExSS.
- **Identifies new targeted technologies needed not yet reported elsewhere**
  - "Laboratory Astrophysics Gap List" White Paper, Fortney *et al.* 2016, identified needed studies to increase the list of informative wavelengths and enhance our ability to interpret spectra
- **Contributes to decadal review efforts for both PSD and APD**
  - 4 NExSS white papers submitted to NAS Astrobiology Strategy study and plan to submit 4-5 to the Exoplanet Exploration Study
  - NExSS asked to present to the NAS Astrobiology Strategy study committee
- **Enhances International engagement**
  - –Invited lectures; travel awards to international conference;
  - 46% participation in JWST Early Release Science working group was international researchers
  - NExSS Directory developed at the request of International attendees to NExSS workshops

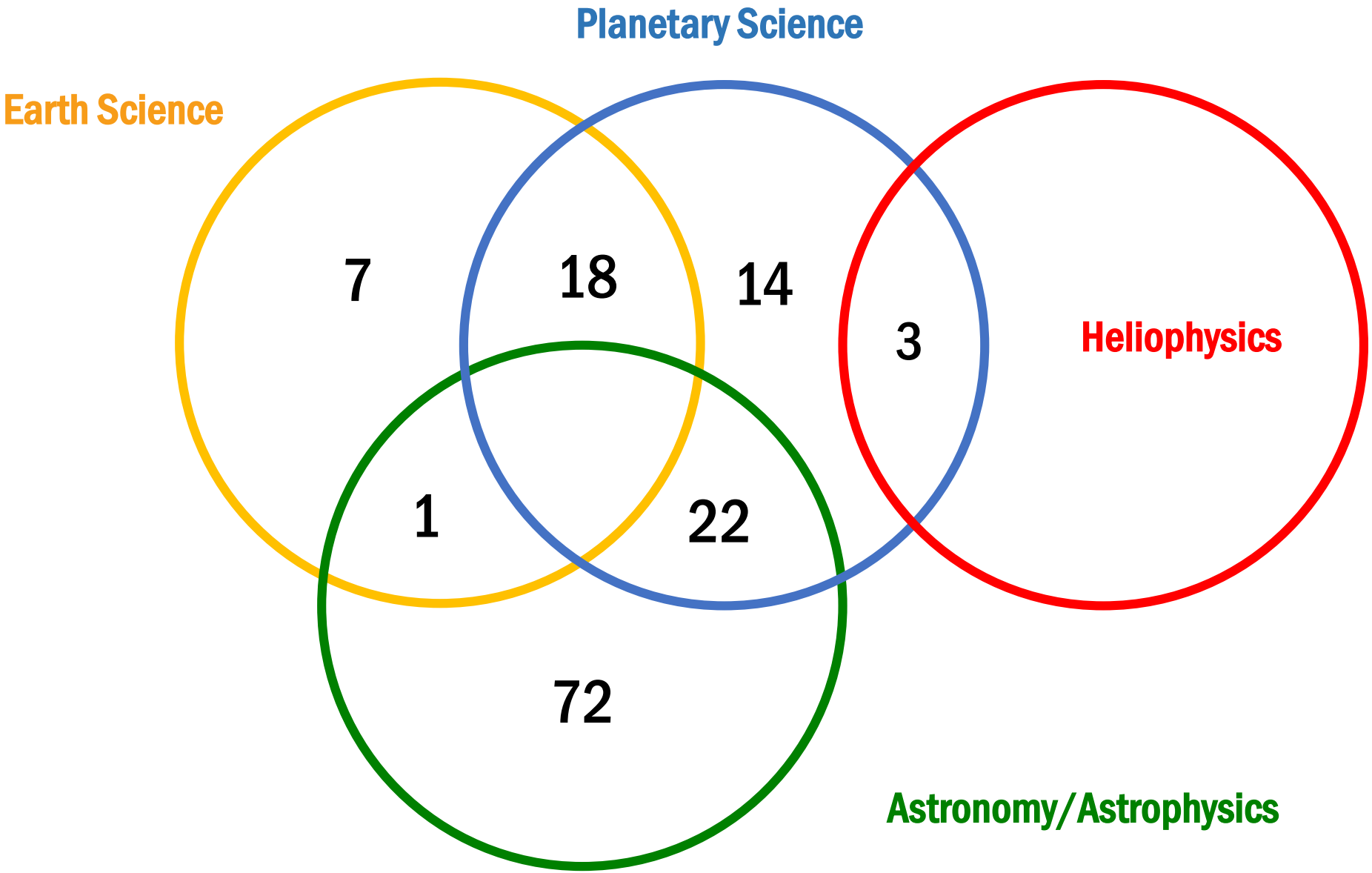
Examples of cross-discipline research by NExSS teams

- Disintegrating exoplanet dust tails as a potential window on the composition of planet interiors
- Geochemical constraints on habitability and detectability of biotic O_2 on aquaplanets
- Space weather effects on atmospheric loss for planets orbiting M-stars
- Bayesian framework for biosignature assessment
- Climate model reassessment of the moist greenhouse HZ inner edge and H_2O detectability

- Laramie, Wy., Nov. 13-17 2017
- First NExSS Conference
- NExSS (57) & non-NExSS (85) attendees
- Emphasis on breakouts, panels, hacks
- Live-streaming of talks and some breakouts
- Balanced contributions from astro, planetary, Earth, and helio
- NASA TV event, Reddit AMA

Diversity of Expertise at HabWorlds*

*Roughly grouped from abstracts/Google Scholar/chats over coffee



72 Astro
63 All else

2.6 Nexus of Exoplanet System Science

Although Habitable Worlds solicits proposals aimed at habitability of any planet, including those within the solar system, PIs of proposals selected for funding from this program element that cover a research topic related to the habitability of, or search for life on, exoplanets specifically are eligible to be part of the Nexus of Exoplanet System Science (NExSS). Relevance to NExSS is not an evaluation criterion for proposals to this program element. Eligibility for participation in NExSS does not indicate that additional funding will be provided; NExSS is a research coordination network that brings together scientists from many disciplines that study planets beyond our Solar System. For more information see https://nexss.info/.

Research Coordination Network

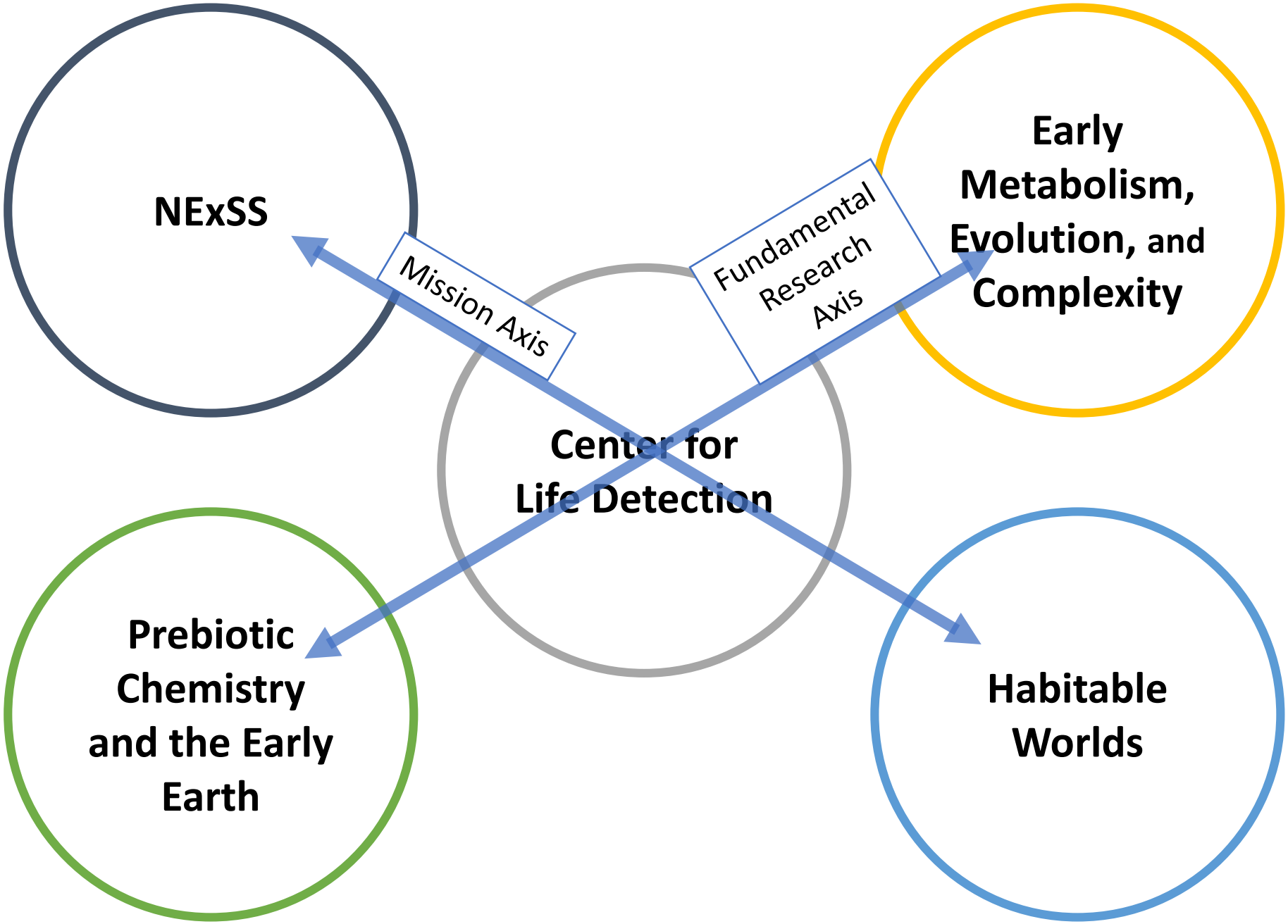
- Research funding chosen through multiple competitions in cooperating divisions.
- Members vary in size ($, researchers)
- Membership does not come with any extra research funding.
- Coordinated through a small team of scientists.
- Very light management burden; few extra services.

Four New NExSS-like Networks (for a total of 5 ARNs)

- **NExSS**
- **Habitable Worlds**
  - **1st iteration Ocean/Icy worlds-focused**
- **Center for Life Detection**
- **Prebiotic Chemistry and the Early Earth**
- **Early Metabolism, Evolution, and Complexity**

ARN Narratives

- **NExSS** – investigate the diversity of exoplanets and to learn how their history, geology, and climate interact to create the conditions for life
- **Habitable Worlds** – investigate the diversity of other worlds in the solar system and to learn how their history, geology, and climate interact to create the conditions for life
- **Center for Life Detection** – investigate life detection research, including biosignature creation and preservation, as well as related technology development
- **Prebiotic Chemistry and the Early Earth** – investigate how small molecules can self-assemble into polymers that resemble basic biological molecules and the conditions on the Early Earth that enabled these reactions
- **Early Metabolism, Evolution, and Complexity** – investigate the earliest biological processes and the evolution of life on Earth into more complex organisms (including multicellularity)


NExSS
Early Metabolism, Evolution, and Complexity
Mission Axis
Fundamental Research Axis
Center for Life Detection
Prebiotic Chemistry and the Early Earth
Habitable Worlds

Program Distribution

NExSS
AB Strategy: 1,4,5,6
Other R&A: HW,XRP,LWS, APD,HPD

Early Metabolism, Evolution, and Complexity
AB Strategy: 2,3,4
Other R&A: N/A
NIH, DOE

Center for Life Detection
AB Strategy: 5
Other R&A: N/A
NSF:OCE

Prebiotic Chemistry and the Early Earth
AB Strategy: 1,2,6
Other R&A: EW, Lab Astro

Habitable Worlds
AB Strategy: 1,4,5,6
Other R&A: SSW, XRP, CDAP
NSF:OCE,OPP

Astrobiology Strategy 2015 Chapters

1. Identifying abiotic sources of organic compounds
2. Synthesis and function of macromolecules in the origin of life
3. Early life and increasing complexity
4. Co-evolution of life and the physical environment
5. Identifying, exploring, and characterizing environments for habitability and biosignatures
6. Constructing habitable worlds

Organization

- Composition – awards of various size and duration from multiple programs
- Leadership – 2-3 PIs representing key areas within theme; will receive augmentation to grant to offset organizational duties; brief report to Senior Scientist for Astrobiology monthly
- Collaboration – multiple time per year virtual or in-person meeting within each of the Research Networks; once per year in-person for all five Networks together (tied to AbSciCon when held)

Measures of Success of ARN

- **Investigators carry out and propose interdisciplinary research through new collaborations**
  - **list of new research topics**
  - **Evidence of new collaborations beyond Astrobiology**
- Produces a plan to inform current mission (if applicable)
- Spawns ideas for new and exciting missions (if applicable)
- Identifies new targeted technologies or instrumentation needed, but not yet reported elsewhere
- Enhances international engagement
- Supports development of early AB community

Center for Life Detection Science (CLDS)

ARC (Hoehler)

the purpose of which will be to:

(i) compile, organize, and curate a “living” repository of information and community dialog relating to life detection science; and

(ii) identify and recommend priority areas for community engagement, research, and technology development that will best support the life detection endeavor.

(iii)The activity will adopt and build on the “Ladder of Life Detection” as its basic structure and actively seek to engage the relevant scientific communities in this process, such that the CLDS can serve as a resource to focus and distill broad-ranging community inputs into organized, easily accessible, and actionable information.

Questions?