



ExEP Science Update

ExoPAG 26

Eric Mamajek & Karl Stapelfeldt

Program Chief Scientists

NASA Exoplanet Exploration Program Office

Jet Propulsion Laboratory, California Institute of Technology

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Astro2020 saw it our way

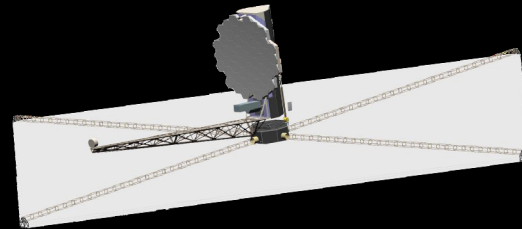
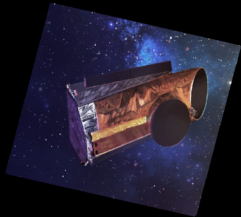
Worlds and Suns in Context

Pathways to Habitable Worlds

Are there habitable planets harboring life
elsewhere in the universe ?

Are humans alone?

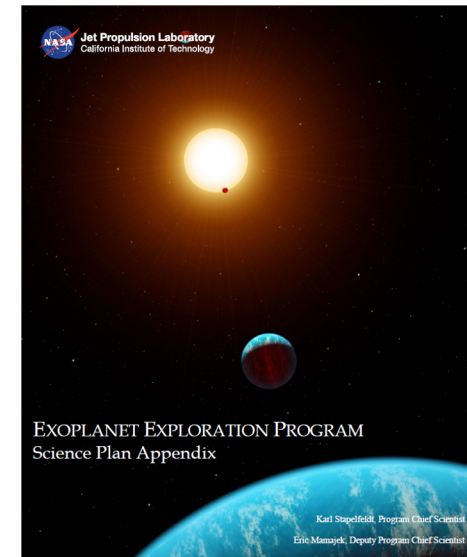
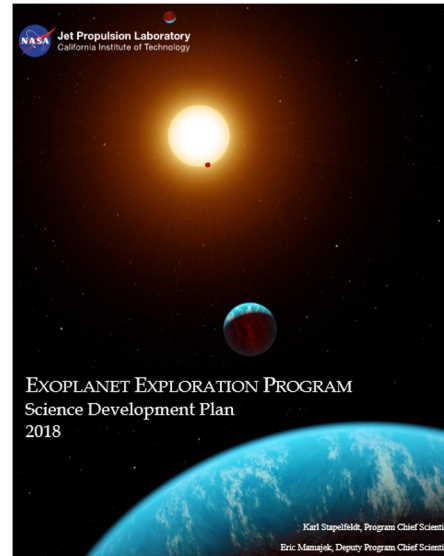
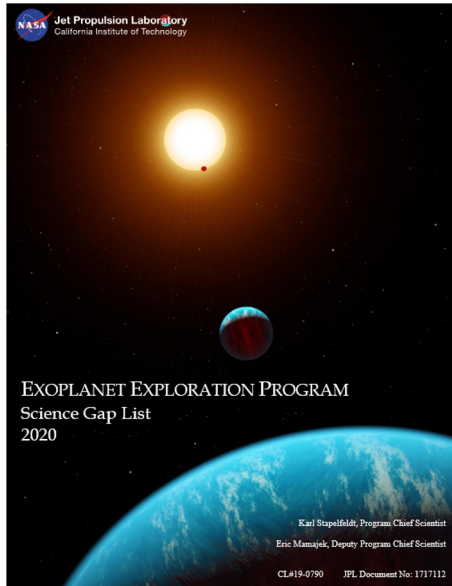
Is the Earth unique ?



Three Exoplanet Program Science Plan documents

“All ExEP approaches, activities, and decisions shall be guided by science priorities”

-- NASA Exoplanet Exploration Program Charter



Authored by ExEP Program Chief Scientists
Karl Stapelfeldt & Eric Mamajek
Reviewed by NASA HQ and the ExoPAG EC

Exoplanet Science Plan and Science Gap List



- The ExEP Science Plan has tactical scope for the implementation of science goals assigned to ExEP by NASA HQ and flowing from community policy documents. It consists of
 - The **Science Gap List** (SGL) specifies 14 research areas where additional work would enhance the science return of current and upcoming NASA missions, or provide info needed for the design of future missions. Updated annually.
 - The **Science Plan Appendix** puts the SGL in context with the state of the field, upcoming missions and facilities, and knowledge needed to inform ExEP objectives in five subdisciplines of exoplanet research. To be updated in 2022.
 - The **Science Development Plan** defines roles and relationships between exoplanet scientists at HQ, Program Office, ExEP Projects, NExSci, and ExoPAG. It also lays out the process for SGL updates. Relatively static.
- Documents at <https://exoplanets.nasa.gov/exep/science-overview/>
- The Science Plan documents are intended for use in proposal solicitation, writing, and evaluation; they were referenced in the [2020/21/22 XRP calls](#) (NASA ROSES Exoplanets Research Program)

What does a science gap look like ?

- Gap definition: *“the difference between knowledge needed to define requirements for specified future NASA exoplanet missions and the current state of the art, or knowledge which is needed to enhance the science return of current and future NASA exoplanet missions.”*
- A science gap is concise enough to be described in roughly 1 page of text and consists of 5 elements :
 - A gap Title & Summary description
 - “Capability Needed”, i.e. the data sets, modeling, or analysis products that would significantly benefit NASA exoplanet missions
 - “Capability Today”, which in comparison to the Capability Needed defines the existing science gap
 - “Mitigations in Progress”, the efforts going on now that are likely to make progress in closing the gap
- We don’t provide a “Mitigations not yet started” element – that’s for individual proposers to conceive of
- To be an Exoplanet Program gap, it needs to be cross-cutting. We leave it to individual projects to track their internal science gaps.

SCI-	Gap Title
1	Spectroscopic observations of the atmospheres of small exoplanets
2	Modeling exoplanet atmospheres
3	Spectral signature retrieval
4	Planetary system architectures: occurrence rates for exoplanets of all sizes
5	Occurrence rates and uncertainties for temperate rocky planets (eta-Earth)
6	Yield estimation for exoplanet direct imaging missions
7	Intrinsic properties of known exoplanet host stars
8	Mitigating stellar jitter as a limitation to sensitivity of dynamical methods to detect small temperate exoplanets and measure their masses and orbits
9	Dynamical confirmation of exoplanet candidates and determination of their masses and orbits
10	Precursor observations of direct imaging targets
11	Understanding the abundance and distribution of exozodiacal dust
12	Measurements of accurate transiting planet radii
13	Properties of atoms, molecules and aerosols in exoplanet atmospheres
14	Exoplanet interior structure and material properties

2022 Science Gap List Revision Process

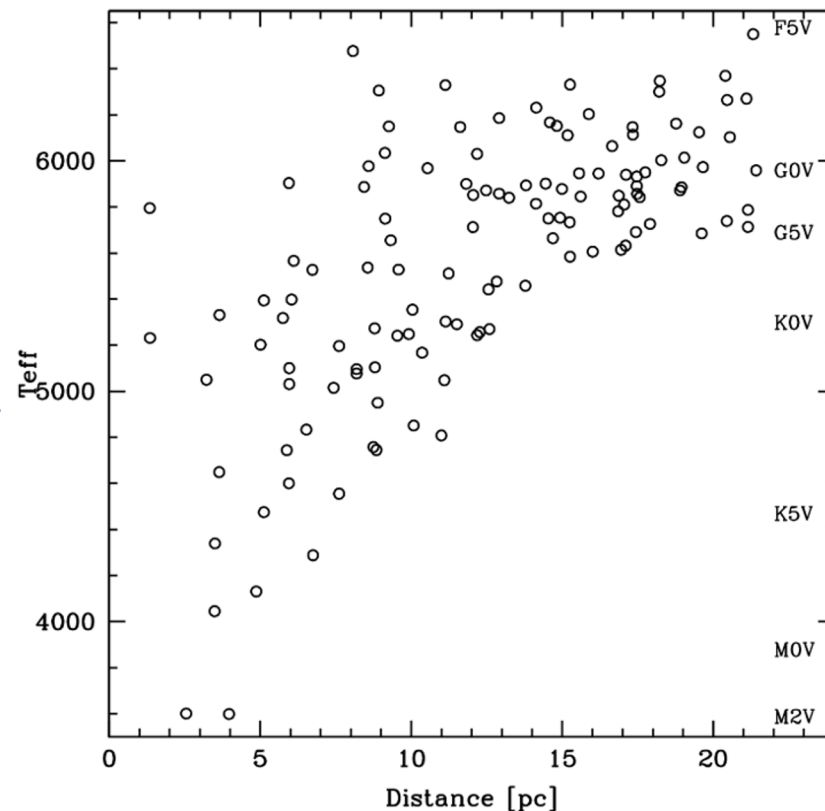


- **ExEP is now requesting community input on the 2022 ExEP Science Gap list.**
- The window for providing input runs through Friday, September 30, 2022.
- Program Chief Scientists will review these inputs, and made their own changes as well, revising the gap list during Oct/Nov 2022, delivering a draft gap list table to our HQ Program Scientists just before the holidays
- The 2023 ExEP Science Gap List will be posted in January 2023, before the 2023 NASA ROSES proposal call (which includes XRP) is posted 2/14/2023.

Separately, the Precursor Science community workshops are independently brainstorming gaps and precursor science needs for the 3 Decadal Future Great Observatories. These will provide input to ROSES call “Astrophysics Decadal Survey Precursor Science” (see talk by T. Brandt Sunday)

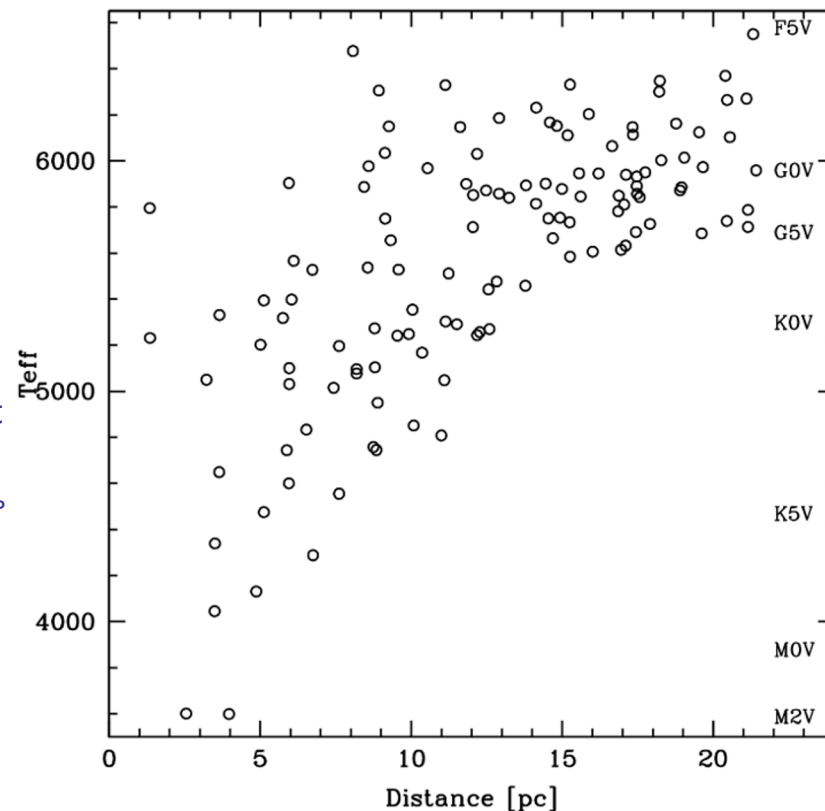
Target List for Precursor & Preparatory Science

- Now that Astro 2020 has settled on the approximate scope for a future IR/O/UV direct imaging mission, *the community can start work towards improving our knowledge of the stars that will likely be the targets for fulfilling the Decadal goal to search for biosignatures from a robust # of ~25 potentially habitable planets* (~100 hab zones surveyed)
- *A refined list of high priority stars needs to be built & made available to the community.*
- The nearby stars with accessible HZs are defined by the inner working angle of the starlight suppression system, the limiting magnitudes and contrasts for making spectra with sufficient S/N, and by binarity issues. *There is little flexibility!*
- Refined list of high priority science targets accounted for LUVOR, HabEx & EPRV WG report target lists, and is filling in missing (~10%) stars with SIMBAD, Hipparcos, Gaia.
- **Carefully vetted:** stellar parameters (esp. luminosities!), V and R magnitudes, binarity (resolved & spectroscopic)



Target List for Precursor & Preparatory Science

- Assumptions:
 - EEID (Earth Equivalent Instellation Distance) = $\sqrt{L/L_{\text{Sun}}}$ au
 - EEID (angular separation, mas) = $1000 \sqrt{L/L_{\text{Sun}}} / D_{\text{pc}}$
 - Raw contrast $1\text{e-}10$, post-processing $4\text{e-}11$ ($\Delta\text{mag}=26$).
 - Geometric albedo = 0.2 (adopted for small planets by HabEx/LUVOIR)
 - Earth twin $R_{\text{mag}} < 31$ (R since considering spectroscopy)
 - Stellar singles + $>5''$ binaries, but retained some borderlines
- Basic selection: trying to keep IWA agnostic to architecture at this point. What are best systems to search for exo-Earths?
Starting with systems where Earth twins at phase = 90° or 65° satisfying star-planet ratio and brightness criteria
- To get to ~100 hab zones surveyed => need IWA $\lesssim 70$ mas**
- Also include ~50 less-than-optimal systems**
- Plan to send out table & documentation to subject matter experts for review after ExoPAG 26. After input received and taken into account, **the catalog will be posted at NExSci site**
- Input systems for “Where We Explore” - see A. Tripathi’s talk



Exoplanets in the 2022 Decadal Survey of Planetary Science & Astrobiology



- Mission recommendations were restricted to the solar system. Existing Programs & Projects, a Uranus orbiter, and an Enceladus “orbilander” were prioritized. See Thursday AAS Town Hall presentation for details
- Per the statement of task from NASA HQ to the National Academies, the scope of the PS & A Decadal exoplanet recommendations was limited to identifying scientific issues and questions, including habitability and comparative planetology. Mission recommendations were not in-scope.
- Chapter 15 provides 27 pages of discussion of the overall question *“What does our planetary system and its circumplanetary systems of satellites and rings reveal about other planetary systems, and what can disks and exoplanets orbiting other stars teach us about the solar system ?”*
 - 35 more detailed questions are posed to address the above
 - 48 strategic research goals are spelled out to make progress
- While many of the above points are disconnected from current & upcoming exoplanet missions, 17 of them specifically call for telescopic observations. **ExoPAG should consider how some of these might be integrated into ExEP Goals and our Science Gap List.**