



ExEP Science Gap List Update

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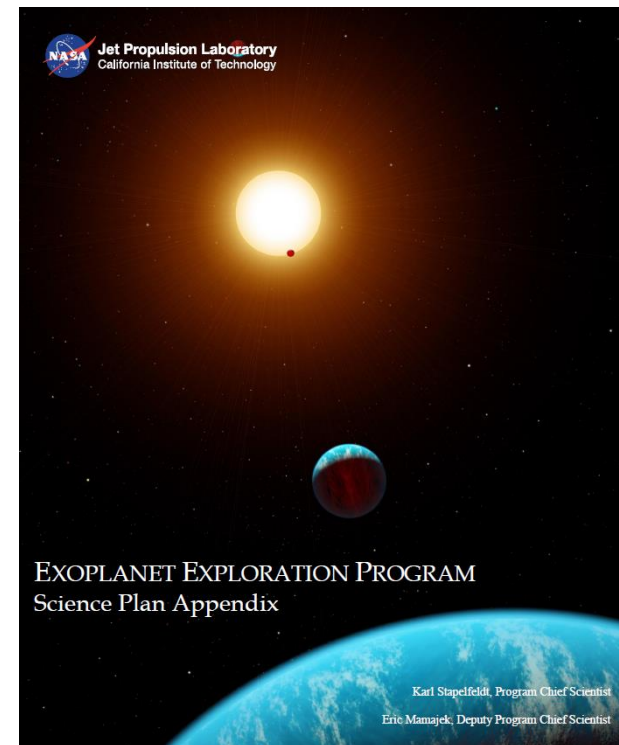
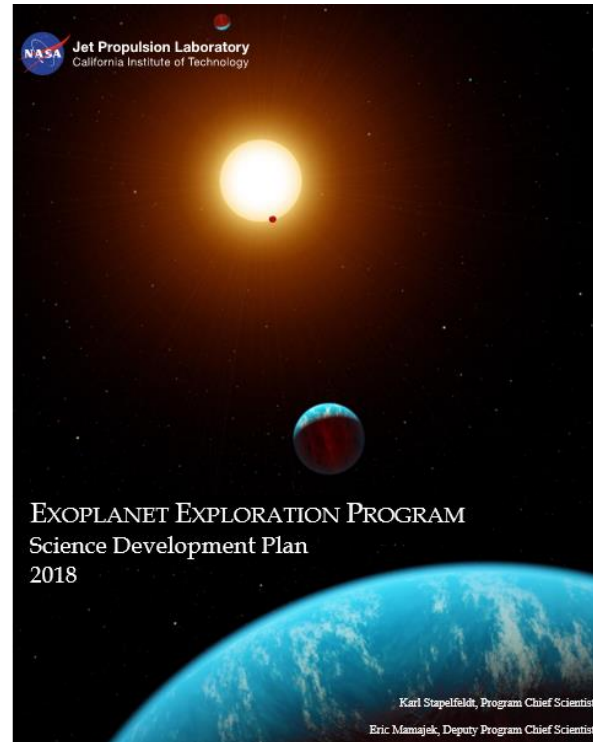
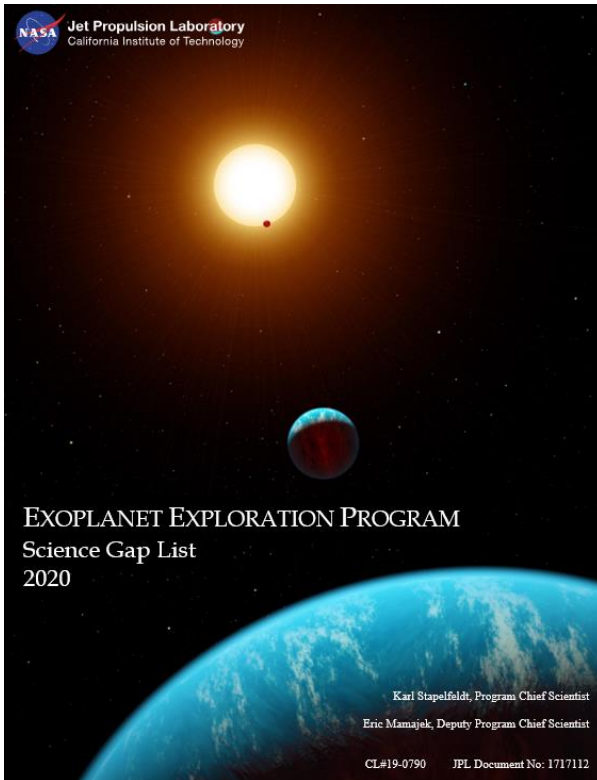
Government sponsorship acknowledged

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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
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Reviewed by NASA HQ and 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 now consists of
 - The **Science Gap List** (SGL) specifies areas where additional work would enhance the science return of current and upcoming missions, or provide info needed for the design of future missions. Updated annually.
 - 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.
 - The **Science Plan Appendix** provides background information on state of the field, upcoming missions and facilities, and knowledge needed to inform ExEP objectives in five subdisciplines of exoplanet research (context for the SGL).
- 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 XRP](#) call ([ROSES E.3 Exoplanets Research](#))

Science Gap List Revision Process



- Community input on the 2020 SGL was solicited at the June 2020 ExoPAG meeting and by emails to the exopagannounce list. The 3 month window for responses closed at the end of Sept. Very good inputs from ExoPAG EC
- Program Chief Scientists revised the gap list during 2020 October & November, delivering a draft gap list table to HQ Program Scientists just before the holidays
- Small updates are needed in response to the HQ comments, with completion expected next week and then the formal signature process
- The 2021 ExEP Science Gap List will be posted later this month, in time to support 2021 ROSES call to be released on 2/14/21.

What does a science gap look like ?



- A science gap is concise enough to be described in roughly 1 page of text and consists of these 5 elements :
 - A gap title
 - Summary description
 - “Capability Needed”, i.e. the data sets, or 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.

2021 Gap List revisions (1)

Gap #01: Spectral characterization of small exoplanets

Added tally of TESS planets suitable for JWST spectroscopy, potential of high contrast imaging combined with high dispersion spectroscopy, **cross-Divisional synergy with disk-integrated spectra of Sol Sys planets**

Gap #02: Modeling exoplanet atmospheres

Explicitly categorized mitigations of this gap as SMD cross-Divisional synergies with Earth & Planetary Science.

Gap #03: Spectral Signature Retrieval

Updated status of community data challenges, need to quantify effects of mass, radius uncertainties on results, referred to ExoPAG SAG 21 effort on limits to transmission spectroscopy.

Gap #04: Planetary system architectures: occurrence rates for exoplanets of all sizes

Updated references, connection to planet formation population synthesis models, need statistics on longer-period planets and planets in multiple star systems, **SMD cross-Divisional synergy with dynamical history of the solar system**

2021 Gap List revisions (2)



Gap #05: Occurrence rates for HZ exoplanets (e.g. $\eta\oplus$)

Emphasized the singular dependence of results on the transit method, referenced important 2020 demographics papers, **added text on SMD cross-Divisional synergy on limits to the HZ (e.g. Venus, Mars)**

Gap #06: Yield estimates for exoplanet direct imaging missions

Expanded description of ExEP standards team results and specified the simplifying assumptions which may be limiting the fidelity of current estimates.

Gap #07: Properties of exoplanet host stars

Distinguished between the info provided by EUV and FUV measurements, referenced Hypatia abundance catalog, added cubesat mitigations in progress for NUV/FUV.

Gap #08: Mitigate stellar jitter as a limitation to exoplanet dynamical measurements

Distinguished needed HZ RV sensitivity vs. host star type. “Mitigations in progress” heavily revised to reflect recommendations of the EPRV working group. **Cross-Divisional synergy to Heliophysics.**

2021 Gap List revisions (3)

Gap #09: Dynamical confirmation of exoplanet candidates, determination of their masses & orbits

Updates on ESPRESSO, NEID, EXPRES, and MAROON-X performance and best recent TTV results

Gap #10: Precursor surveys of direct imaging targets

Pointed out detecting larger planets will provide dynamical context for the HZ, referenced EPRV WG's target classifications and SAG 22's role in identifying needed datasets.

Gap #11: Understand the abundance and distribution of exozodiacal dust

Updates reflect final LBTI/HOSTS survey results, mention the unknown connection between NIR hot dust and HZ dust, and the potential role of ELTs. **Added text on SMD cross-Divisional synergy with IPD studies.**

Gap #12: Measurement of accurate transiting planet radii

Emphasized that deblending the targets is the greatest issue, not intrinsic stellar radii post Gaia-DR2. Expanded the list of options for TESS imaging follow-up.

*** Two NEW Science Gaps ***

Gap #13: Properties of Atoms, Molecules and Aerosols in Exoplanet Atmospheres

Spun off from Gap #02 on modeling exoplanet atmospheres. Much-expanded description of numerical and laboratory work needed to provide reliable molecular constants under relevant conditions, and adding consideration of aerosols.

Gap #14: Modeling Exoplanet Interiors

Spun off from Gap #02 on modeling exoplanet atmospheres. The wide range of radii for planets in the 5-10 M_{\oplus} range needs further investigation, including outliers such as super-puffs. Need for lab work on material properties at high pressures & temperatures.

Cross-Agency synergies with NSF

2021 Process for Science Gap List Revisions



- Will follow similar process & schedule as last year: After XRP proposal deadline, at ExoPAG summer 2021 meeting, will call for community inputs to update the SGL.
- Astro2020 results could create new gaps, will be interesting to see what changes will be needed to the SGL
- Open comment period through September, internal NASA work on revisions during the Fall, leading to a new SGL by January 2022.
- In 2021 we will also update the 60-page Science Plan appendix to reflect progress in the field, take into account the Decadal Survey recommendations, and follow NASA HQ's Astrophysics Implementation Plan response to the Decadal.

We are eager to see the community close these science gaps
through innovative research !