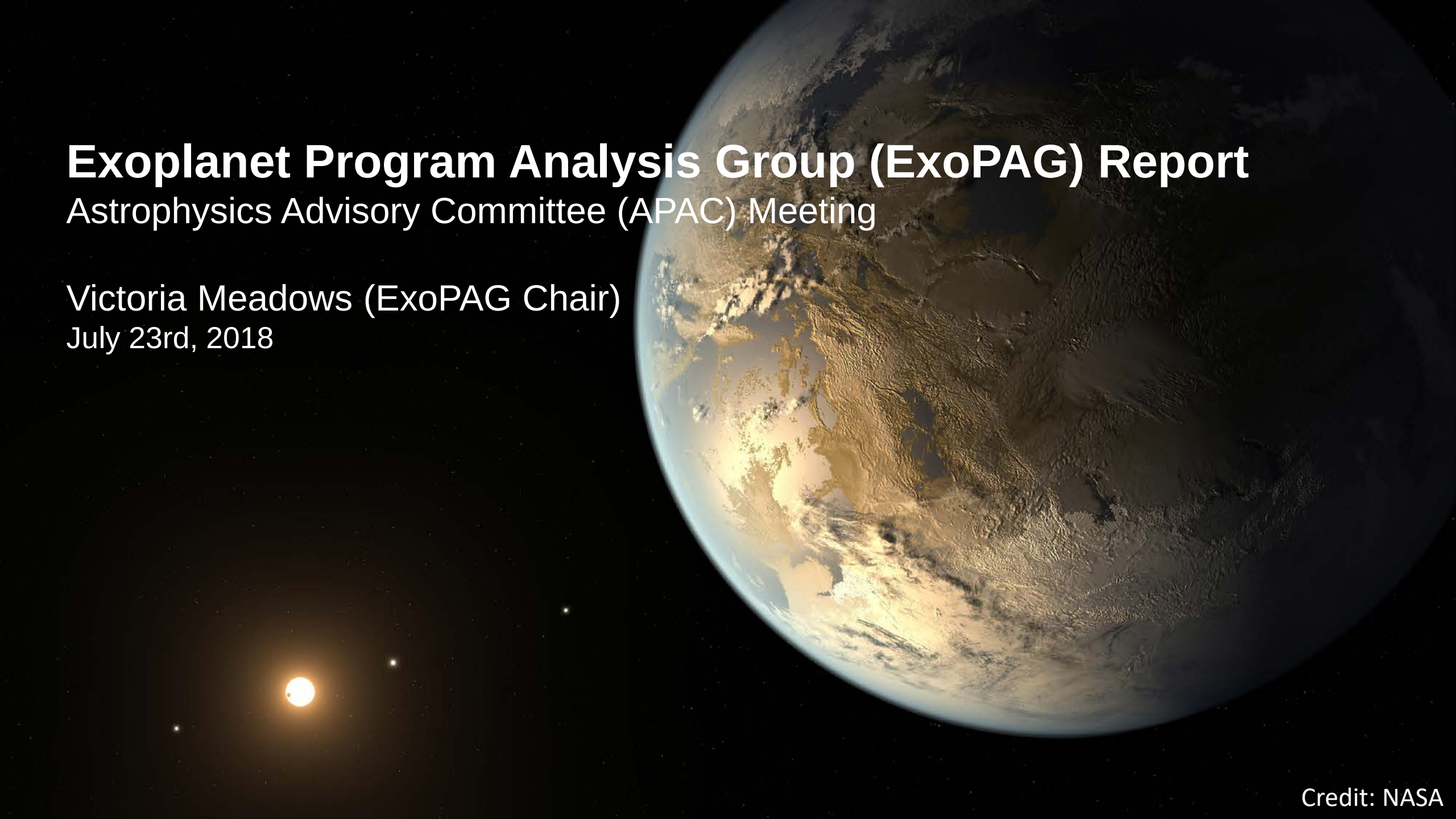
Exoplanet Program Analysis Group (ExoPAG) Report

Astrophysics Advisory Committee (APAC) Meeting

Victoria Meadows (ExoPAG Chair)

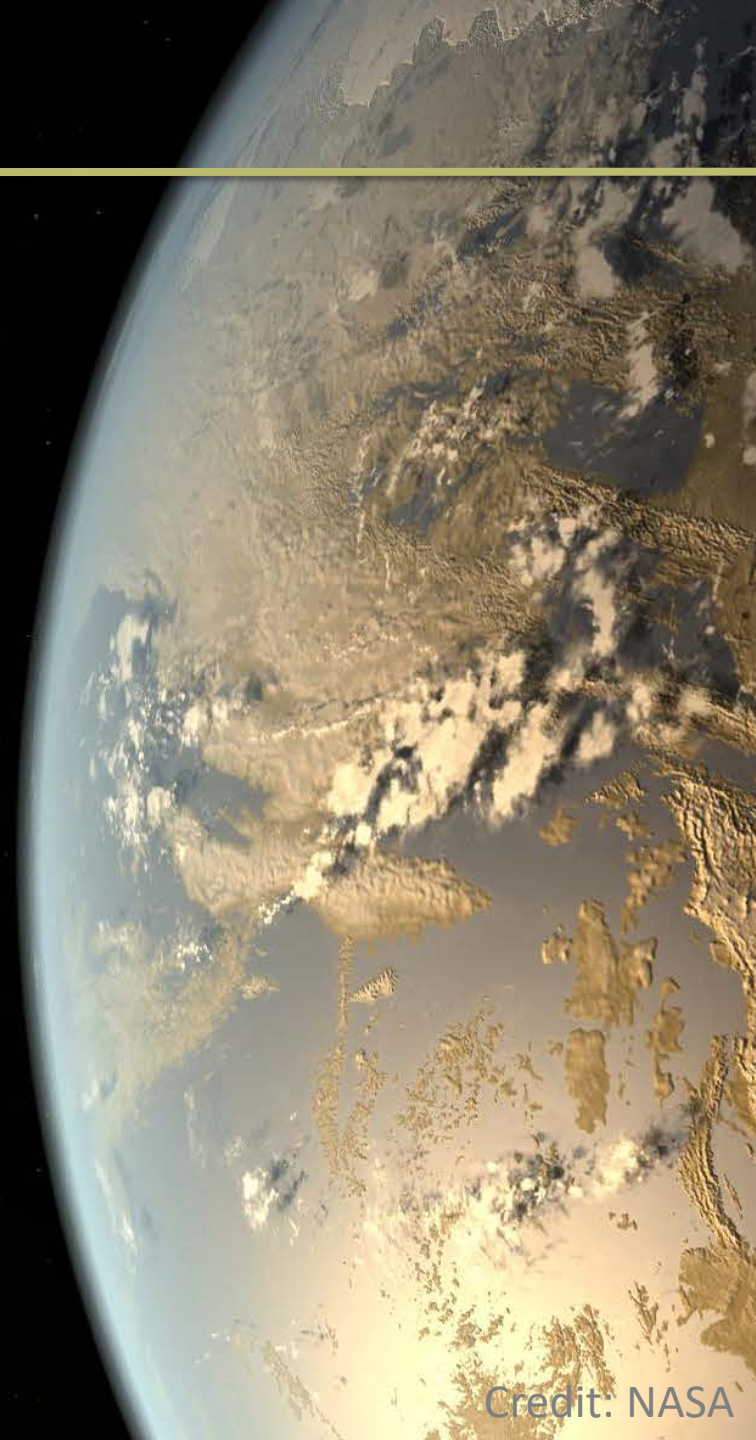
July 23rd, 2018



Credit: NASA

ExoPAG EC Membership

Victoria Meadows (Chair)	**University of Washington**
Tom Barclay*	Goddard Space Flight Center
Jessie Christiansen*	NExScI/Caltech
Rebecca Jensen-Clem*	UC-Berkeley
Tiffany Glassman	Northrup Grumman Aerospace Systems
Eliza Kempton	University of Maryland
Dimitri Mawet	Caltech
Michael Meyer	University of Michigan
Tyler Robinson	Northern Arizona University
Chris Stark	Space Telescope Science Institute
Johanna Teske	Carnegie Observatories **-> DTM**
Daniel Apai	University of Arizona
David Ciardi	NExScI/Caltech
Shawn Domagal-Goldman	NASA Goddard Space Flight Center
Alan Boss (Past Chair)	Carnegie Institution of Washington
Martin Still (Ex officio)	NASA



Credit: NASA

3 Active Study Analysis Groups (SAGs)

Year	SAG	Title	Lead
2018	16	Exoplanet Biosignatures (requesting closeout at this meeting)	Domagal-Goldman
--	17	Community Resources Needed for K2 and TESS Planetary Candidate Confirmation (active - closeout expected in 2018)	Ciardi & Pepper
--	19	Exoplanet imaging signal detection theory and rigorous contrast metrics (active - closeout expected in 2018)	Mawet & Jensen-Clem

ExoPAG Recent Activities

- Kempton and Robinson led an effort to submit a community letter to the JWST Users Committee (JSTUC), making the case for large multi-cycle legacy proposals to support community-led proposals.
  - The letter was co-signed by 55 members of the exoplanet observing community.

- Robinson led the ExoPAG EC in the organization of the agenda for the ExoPAG18 meeting to be held in Boston, July 29th, in conjunction with the Cool Stars 20 conference.
  - New format with mini-science symposium on M dwarf/planet interactions
  - Showcase for relevant CubeSat missions.

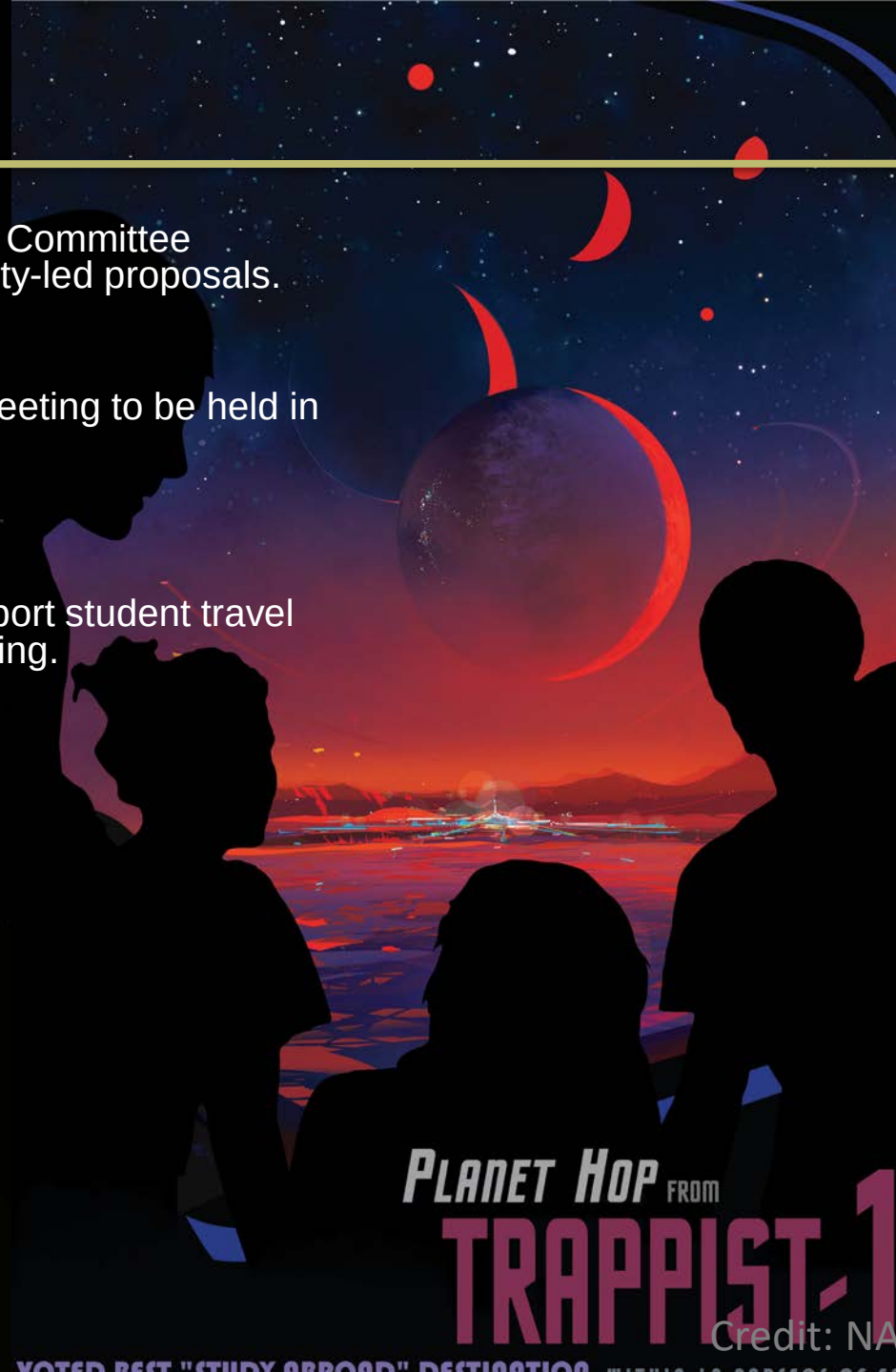
- Jensen-Clem and Ciardi initiated and organized a new ExEP-funded program to support student travel to ExoPAG meetings. 4 students were selected by the ExoPAG EC for the July meeting.
  - Molly Kosiarek (UC-Santa Cruz)
  - R.O. Parke Loyd (ASU)
  - Benjamin Rackham (UofA)
  - Ellianna Schwab (UC-Berkeley/AMNH)

- Closeout of SAG16 presented by Domagal-Goldman to ExoPAG EC on May 3rd.

- ExoPAG EC feedback provided on the ExEP Science Gap List.

- ExoPAG EC commented on the Decadal Delay Survey Report.

- Meyer and Christiansen led the discussion of the initiation of SIG2, charter drafted.



SAG 16: Exoplanet Biosignatures

Leadership: Domagal-Goldman, Kiang, Parenteau)

Science Goals: To address 3 broad questions:

1) What are known remotely observable biosignatures, the processes that produce them, and their known nonbiological sources?

2) How can we identify additional biosignatures, and a more comprehensive framework for biosignature assessment?

3) What are the requirements for detecting these biosignatures to different levels of confidence?

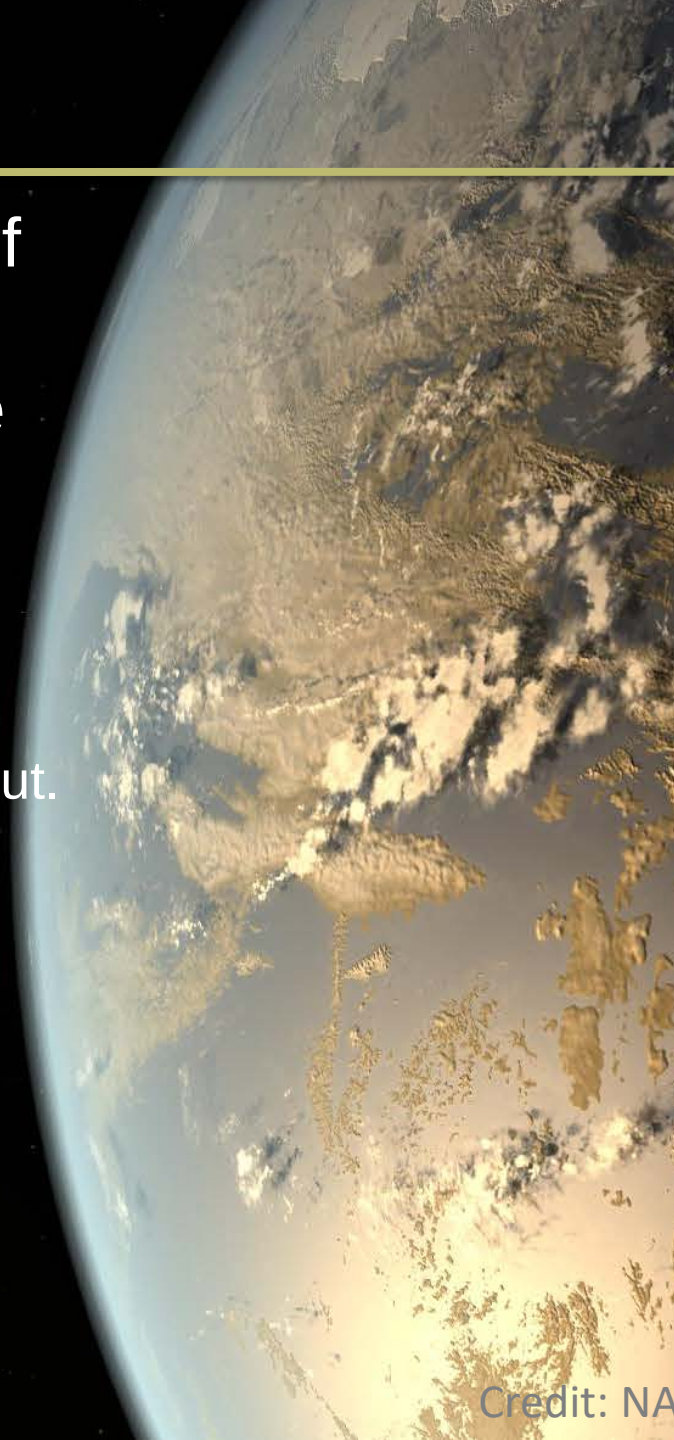
Activity: Organized an in-person/virtual NExSS workshop in 2016 with extremely broad community participation to address fundamental scientific questions that will enhance the science return from NASA exoplanet characterization missions.

Credit: NA

SAG16: Exoplanet Biosignatures - Closeout

- SAG16 (Exoplanet Biosignatures) – As a direct outcome of the 2016 workshop, five community-led review papers on Exoplanet Biosignatures and an Executive Summary were published in the June issue of *Astrobiology*.
  - The published Executive Summary also serves as the SAG 16 report.
    - https://www.liebertpub.com/doi/10.1089/ast.2018.1862
  - Closeout presentations were given by Shawn Domagal-Goldman at the January ExoPAG 19, and to the EC on May 3rd, the EC approved closeout.

- *We are now requesting closeout of SAG 16: Exoplanet Biosignatures from the APAC.*



Initiation of SIG 2 – Exoplanet Demographics

- Leadership: Christiansen & Meyer (ExoPAG EC) + 3 community members who will be recruited upon SIG initiation.

- Motivation: Exoplanet demographics can reveal processes that control planet formation, migration and evolution, and are crucial for predicting the yields of future missions.

- Goal: To build on the Kepler-centric demographics of SAG13 and synthesize information from different surveys, to ultimately provide quantified, independent yield comparisons that can be used by different mission concepts.

- Initial foci: To combine the latest demographic results from transit, RV, microlensing, astrometry, direct imaging to:
  - Extend the analysis for Sun-like stars to larger separations.
  - Examine trends for host stars that vary by mass, composition and age.
  - Explore effects of different formation environments (e.g. stellar multiplicity).

Credit: NA

ExoPAG 2018 Future Activities

- Hold ExoPAG18 on July 29th, 2018, prior to Cool Stars 20 in Boston, MA.
- Continue monthly ExoPAG EC telecons
- Continue working with ExEP towards a public ExEP Science Plan and Science Gap List.
- Finish work of two remaining SAGs – 17,19 and request closeout
- Initiate SIG2 and solicit community participation
- Participate in Great Observatories SAG with CoPAG and PhysPAG.
- Continue to review ExEP Technology Gap List planning process

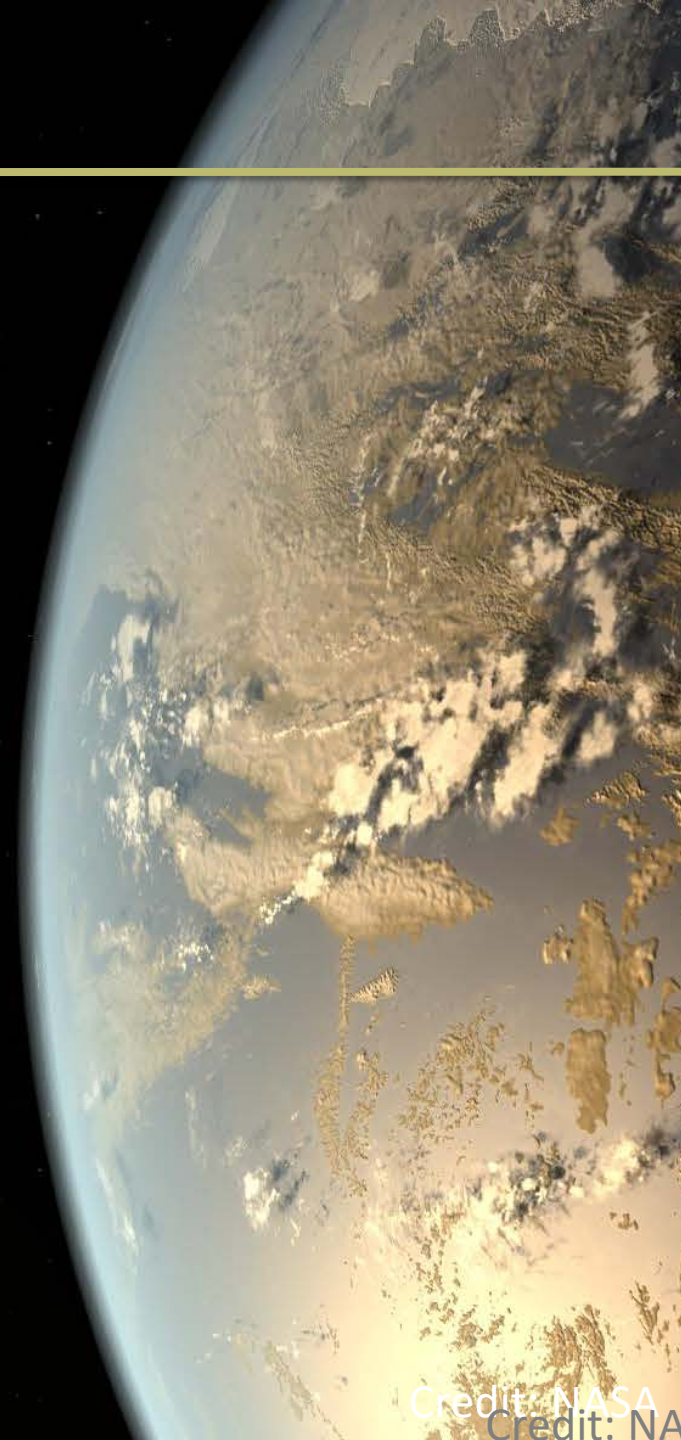
APAC Action Requested by ExoPAG EC

- Closeout SAG 16
- Initiate SIG 2

Backup Slides

11 Completed Study Analysis Groups (SAGs)

Year	SAG	Title	Lead
2012	1	Debris Disks & Exozodiacal Dust	Roberge
2010	2	Potential for Exoplanet Science Measurements from Solar System Probes	Bennett, Coulter
2013	5	Exoplanet Flagship Requirements and Characteristics	Noecker, Greene
2015	8	Requirements and Limits of Future Precision Radial Velocity Measurements	Latham, Plavchan
2015	9	Exoplanet Probe to Medium Scale Direct-Imaging Mission Requirements and Characteristics	Soummer
2015	10	Characterizing the Atmospheres of Transiting Planets with JWST and Beyond	Cowan
2014	11	Preparing for the WFIRST Microlensing Survey	Yee
2017	12	Scientific potential and feasibility of high-precision astrometry for exoplanet detection and characterization.	Bendek
2017	13	Exoplanet Occurrence Rates and Distributions (closed out since last June)	Belikov
2017	15	Exploring Other Worlds: Observational Constraints and Science Questions for Direct Imaging Exoplanet Missions (closed out since June)	Apai
2017	18	Metrics for Direct-Imaging with Starshades (closed out since last June)	Glassman & Turnbull



Agenda- ExoPAG 18

July 29, 2018 Hyatt Regency Cambridge, MA President's Ball Room

9:00 AM	Welcome	Vikki Meadows	
9:05 AM	NASA HQ Updates	Martin Still	
9:25 AM	Exoplanet Exploration Program (ExEP) Updates	Gary Blackwood/Kendra Short/Karl Stapelfeldt/Eric Mamajek	
9:50 AM	Technology Update	Nick Siegler and Brendan Crill	
10:10 AM	WFIRST CGI Status	Feng Zhao and John Trauger	
10:35 AM	**Break**		
10:50 AM	Status- Community Resources Needed for K2 and TESS Planetary Candidate Confirmation	David Ciardi and Josh Pepper	SAG #17
11:00 AM	Status- Exoplanet Imaging Signal Detection Theory and Rigorous Contrast Metrics	Rebecca Jensen-Clem	SAG #19
11:10 AM	Scope and Charter Discussion	Jessie Christiansen	SIG #2
11:30 AM	Open Discussion- Collect Inputs to Program	Gary Blackwood and Kendra Short	
12:00 PM	Wrap Up, Action Items, Future Meetings	Vikki Meadows	
12:10 PM	**Lunch**		
1:30 PM	Arcsecond Space Telescope Enabling Research in Astrophysics	ASTERIA CubeSat: Mary Knapp, MIT	
1:50 PM	Star-Planet Activity Research CubeSat	SPARCS Cubesat: Evgenya Shkolnik, ASU	
2:05 PM	Colorado Ultraviolet Transit Experiment	CUTE Cubesat: Aline Vidotto, Trinity College Dublin	

2:20 PM	**Mini-Symposium**		
2:20 PM	Frontiers in M Dwarf Radial Velocity Surveys	Cullen Blake	
2:50 PM	Exoplanet Distributions for Cool Stars	Courtney Dressing	
3:20 PM	**Break**		
3:35 PM	Expanding our Understanding of M Dwarfs in the Kepler Field	Elliana Schwab Abrahams	
3:50 PM	Linking Stellar Abundances and Exoplanets	Diogo Souto	
4:05 PM	Bright Opportunities for Atmospheric Characterization of Small Planets	Molly Kosiarek	
4:20 PM	Transit Light Source Effect	Benjamin Rackham	
4:35 PM	FUV Flares on M Stars	R.O. Park Loyd	
4:50 PM	Atmospheric Evolution and Loss for M Dwarf Planets	Laura Schaefer	
5:05 PM	M Dwarfs from a GAIA Perspective	Jackie Faherty	
5:20 PM	**Break for Panel Set Up**		
5:25 PM	Discussion Panel		
6:00 PM	Adjourn		
Adobe Connect	https://ac.arc.nasa.gov/exopag	Audio: Toll Free 844-467-6272 Passcode: 103899	

SAG 13: Exoplanet Occurrence Rates and Distributions (Rus Belikov, Chair)

Key objectives and questions:

1. Propose standard nominal conventions, definitions, and units for occurrence rates/ distributions to facilitate comparisons between different studies.
2. Do occurrence estimates from different teams/methods agree with each other to within statistical uncertainty? If not, why?
3. For occurrence rates where extrapolation is still necessary, what values should the community adopt as standard conventions for mission yield estimates?

Recent Progress:

- Computation/crowdsourcing of eta tables
- 11 participants submitted tables so far
- Latest estimates of occurrences of potentially habitable planets seem to be converging (at least to a factor of ~2-3), and explanations for discrepancies are starting to clarify
- Expected product in mid 2017: estimates of occurrence rates

SAG 15: Exploring Other Worlds: Observational Constraints and Science Questions for Direct Imaging Exoplanet Missions (Daniel Apai, Chair)

Charge:

1) What are the most important science questions in exoplanet characterization, apart from biosignature searches?
2) What type of data (spectra, polarization, photometry), with what quality (resolution, signal-to-noise, cadence), is required to answer these science questions?

Progress:

- SAG15 underway and on track
- Team, timeline, process, milestones identified
- Up-to-date status and documents: eos-nexus.org/SAG15/
- Currently finishing work on list of high-level science questions
- Target date for completion Spring 2017
- Report + refereed publication are foreseen
- Interactions with WFIRST and Large Mission STDTs important

SAG 16: Biosignatures (Shawn DomagalGoldman, Nancy Kiang, and Niki Parenteau, Co-Chairs)

Science Goals

We seek to answer 3 broad questions:

1) What are known remotely observable biosignatures, the processes that produce them, and their known nonbiological sources?

2) How can we identify additional biosignatures, and a more comprehensive framework for biosignature assessment?

3) What are the requirements for detecting these biosignatures to different levels of confidence?

A 3-day workshop was held on July 27-29, 2016, along with the NASA Astrobiology Institute (NAI) and the Nexus for Exoplanet System Science (NExSS). Plan is to draft a SAG report and a peer-reviewable paper by mid 2017, invite review and commentary from the community, and submit final SAG report by end of 2017.

SAG 17 – Community Resources Needed for K2 and TESS Planetary Candidate Confirmation (David Ciardi and Joshua Pepper, Co-Chairs)

- SAG 17 will study and enumerate the resources needed by the community to effectively and efficiently validate as many K2 and TESS candidates as possible, and propose methods to allow the community to coordinate and self-organize the process.
- Specific goals of SAG 17 include the following:
- Identify needed follow-up observations for K2 and TESS including but not limited to imaging, spectroscopy, and time-series follow-up
- Identify telescopes, instrument, and financial resources available to the US community
- Identify how archival resources can be utilized (e.g., Gaia)
- Identify how the community can be organized and communication facilitated particularly with regards TESS full frame images, candidate identification, single transiting events, and candidate prioritization.
- Identify needs to ensure efficient and effective characterization with JWST (and WFIRST)
- Identify connections to other SAG efforts (e.g., SAGs 15 and 16)

SAG 19 – Exoplanet Imaging Signal Detection Theory and Rigorous Contrast Metrics (Dimitri Mawet and Rebecca Jensen-Clem, Co-Chairs)

- Go back to the basics of Bayesian Signal Detection Theory (SDT), i.e., H0:signal absent / H1:signal present hypothesis testing.
- Rebuild a solid set of usual definitions used for or in lieu of “contrast” in different contexts, such as astrophysical contrast or ground truth, instrumental contrast used for coronagraph/instrument designs, and the measured onsky datadriven contrast.
- Identify what we can learn and apply from communities outside our field (e.g. medical imaging: receiver operating characteristic (ROC) curve).
- Define precise contrast computation and ROC curve computation recipes, a new “industry standard”.
- Identify how the new metrics and recipes can be used to define confidence levels for detection (H1) and subsequently error bars for photometric, spectroscopic, astrometric characterization.
- Perform a community data challenge before and after applying our proposed set of standardized SDT rules and recipes, and apply lessons learned.