Exoplanet Program Analysis Group (ExoPAG) Report
Astrophysics Advisory Committee (APAC) Meeting

Victoria Meadows (ExoPAG Chair)
Oct 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**
Alan Boss (Past Chair)	Carnegie Institution of Washington
Martin Still (ex officio)	NASA

Status of SAGs and SIGs

Year	SAG or SIG	Title	Lead
2018	SAG 16	Exoplanet Biosignatures (closed)	Domagal-Goldman
2018	SAG 17	Community Resources Needed for K2 and TESS Planetary Candidate Confirmation (requesting closeout at this meeting)	Ciardi & Pepper
--	SAG 19	Exoplanet imaging signal detection theory and rigorous contrast metrics (active - closeout expected in 2019)	Mawet & Jensen-Clem
--	SIG 2	Exoplanet Demographics (Initiated at last meeting)	Christiansen & Meyer
--	SAG 20	Impact of JWST Delay on Exoplanet Science (requesting initiation at this meeting)	Teske & Deming

Credit: NA

ExoPAG Recent Activities

- Robinson led the ExoPAG EC in agenda development for the ExoPAG19 meeting to be held in Seattle, Jan 5-6, 2019, prior to the Winter AAS.
  - Mini-science symposium on characterization of nearby planetary systems.
  - Showcase for exoplanet inputs to the Decadal Survey.

- Additional call for an ExEP-funded program to support student travel to the ExoPAG19 meetings. Deadline Nov 1. Stark to administer program with ExEP.

- Closeout of SAG17 presented by Ciardi to ExoPAG18 on July 29th.

- Teske and Deming developed the charter for SAG 20 on the impact on exoplanet science of the JWST delay, and strategies for mitigation.

- Mawet and Jensen-Clem are organizing a community data challenge for ground-based direct detection as the final phase of the SAG 19 activities.
  - Goal is the fair comparison of algorithms for post-processing high-contrast imaging sequences.

- Meyer and Stevenson participation in the Great Observatories cross-PAG SAG

- EC presentation on NAS Exoplanet Strategy by Gaudi and Meadows.

- Google spreadsheet for community coordination of Decadal White Papers released on ExoPAG website.

PLANET HOP FROM TRAPPIST-1

Credit: NA

SAG 17: Community Resources Needed for K2/TESS Planetary Candidate Confirmation

Leadership: David Ciardi (NExSci/Caltech), Josh Pepper (Lehigh), Knicole Colon (NASA GSFC), Stephen Kane (UC Riverside).

Goals:

1) Identify needed follow-up observations for K2 and TESS

2) Identify resources available to the US community

3) Identify how archival resources can be utilized

4) Identify how the community and resources can be organized.

Activity: Telecons and community input at ExoPAG meetings.
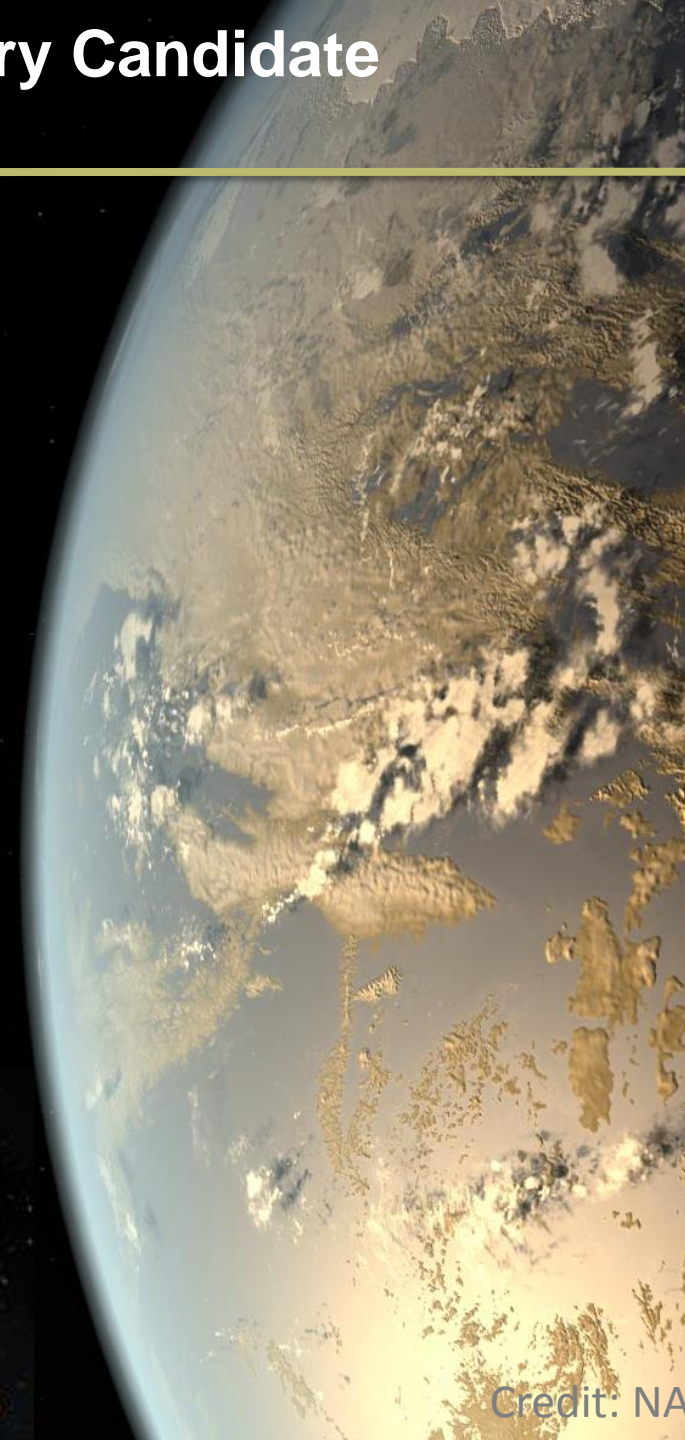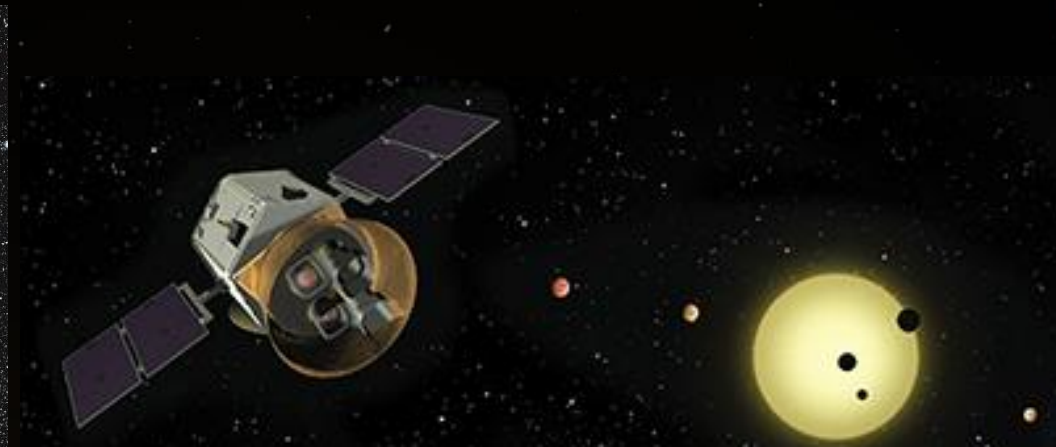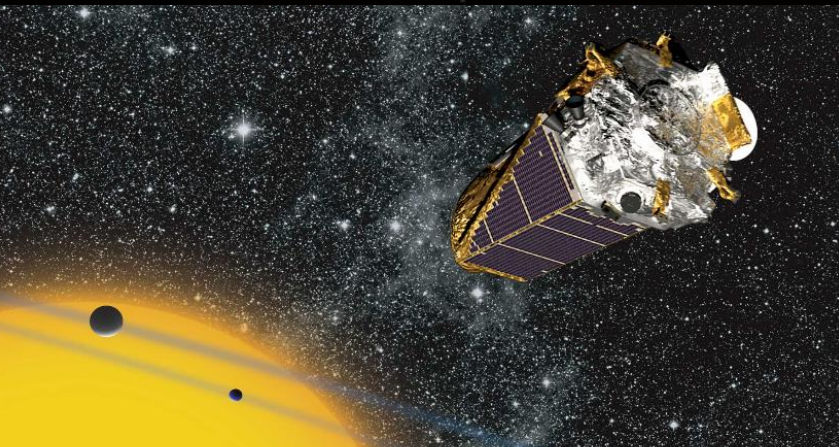
Credit: NA

- The SAG 17 Final Report was presented by Dave Ciardi at the July ExoPAG meeting in Boston, and is now available on the ExoPAG website.
  - https://exoplanets.nasa.gov/internal_resources/942/

- The main conclusions of the report are as follows:
  - Ground-based observations are critical for the success of the transit missions. Without ground-based observations, the scientific goals of the missions can not be met. The ground-programs are as significant to the missions as the spacecraft themselves.
  - Ground-based telescopes are needed to validate, confirm, and characterize exoplanets. Needed resources include telescopes spanning 1-m class through 10-m class, with wide-field imaging, high angular resolution imaging, moderate-resolution (R~3000 or greater) and precision radial velocity spectrographs.
  - Financial resources are needed to support the necessary ground-based follow-up work of students, postdoctoral scholars, and early-career scientists.

- *Closeout of SAG 17 was discussed and recommended by the ExoPAG EC and we are now requesting closeout of SAG 17.*

Credit: NA

SIG 2 – Exoplanet Demographics

- **Leadership:** Christiansen & Meyer (ExoPAG EC) + 3 community members

- **Motivation:** Exoplanet demographics reveal planet formation, migration and evolution processes, and are key to predicting the yields of future missions.

- **Goal:** To augment the Kepler-centric demographics of SAG13 to ultimately provide quantified, independent yield comparisons for mission concepts.

- **Progress to date:**
  - Initiated in July 2018
  - Call for membership of SIG and Steering Committee in August
  - 14 SIG members so far and 4 Steering Committee Members
  - Diversity recruitment efforts ongoing
  - First Steering Committee telecon this week
  - Full SIG kick off telecon planned for November

Credit: NA

SAG 20: Strategies for Mitigating the Impact of the JWST Delay on Exoplanet Science

- Leadership: JohannaTeske (ExoPAG EC) and Drake Deming (UMD)

- Motivation: The JWST launch delay will have negative and positive impacts on our community. Better understanding these may help us outline a strategy for mitigation of adverse effects and enhancement of the science return.

- Goal: To gather and summarize input from the exoplanet community regarding how the JWST delay will affect their science, and the overall scientific return of JWST, and what actions (funded or unfunded) taken between now and the JWST launch could mitigate the impact, or even enhance, their and others' JWST science return.

- Activity: Online community survey and subsequent report and analysis. Final product is a white paper to APD with anticipated impacts and community recommendations, to be completed within 6 months of initiation of the SAG.

- *The ExoPAG EC recommends initiation of this SAG and requests approval of its initiation.*

Credit: NA

ExoPAG 2018/2019 Future Activities

- Hold ExoPAG19 on Jan th, 2019, prior to AAS in Seattle, WA.

- Select students for travel scholarships

- Continue monthly ExoPAG EC telecons

- Continue working with ExEP towards a public ExEP Science Plan and Science Gap List.

- Finish work of SAG-19 and request closeout

- Finalize SIG2 membership and initiate activities

- Participate in Great Observatories SAG with CoPAG and PhysPAG.

- Develop exoplanet community statement on NAS reports and white paper strategy.

Credit: NA
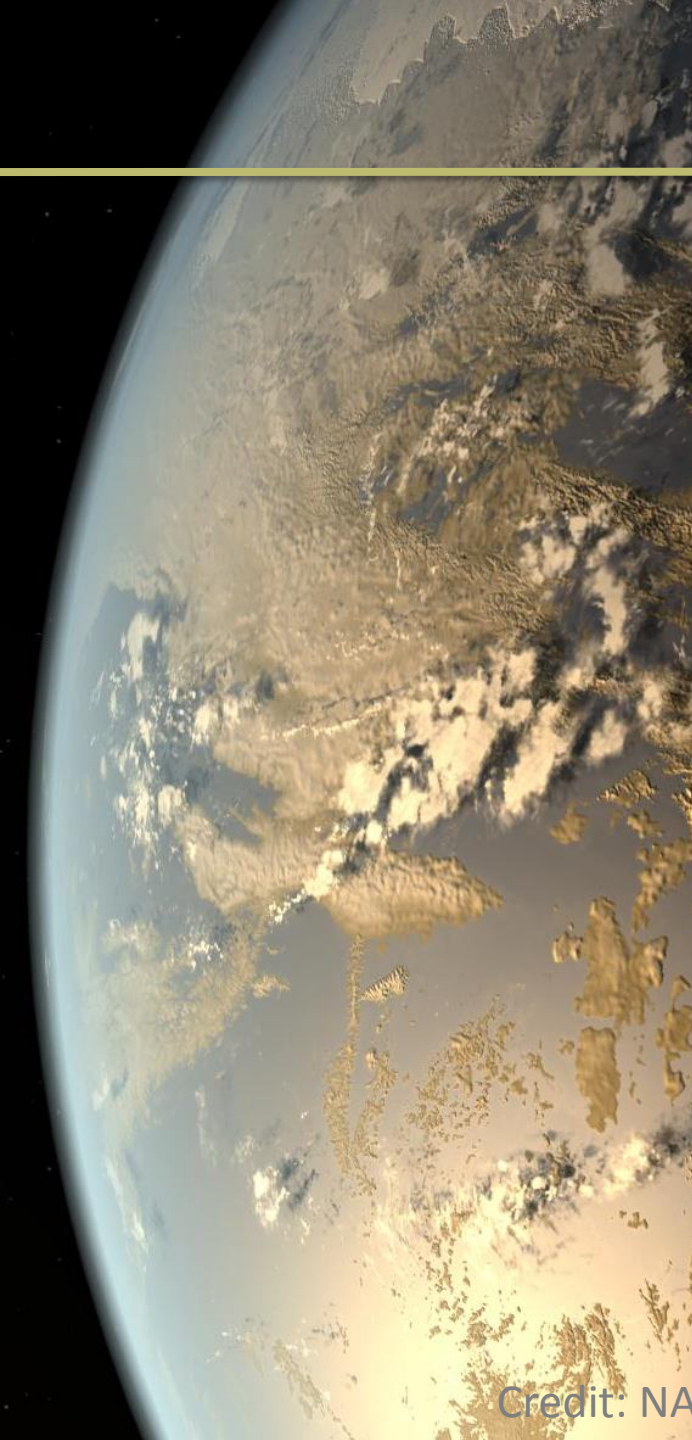
Action Requested by ExoPAG EC

- Closeout SAG 17

- Initiate SAG 20

Backup Slides

Credit: NA
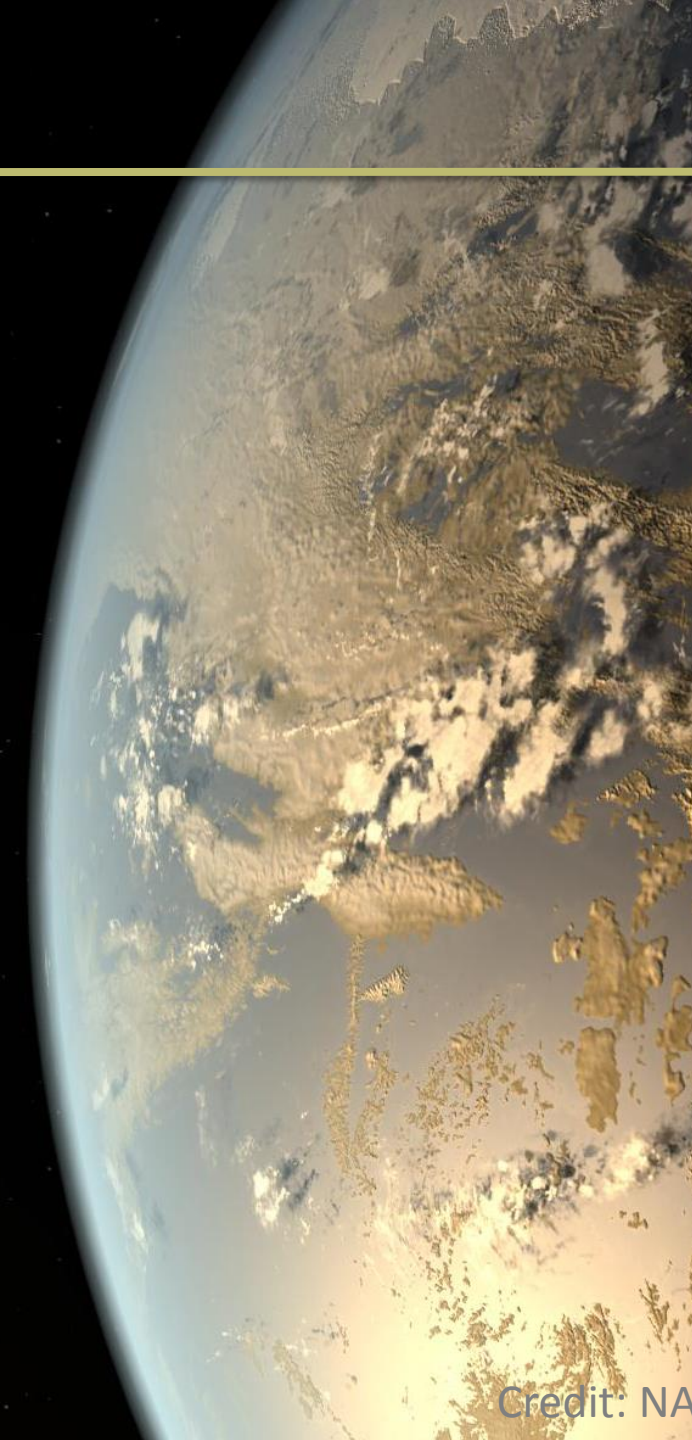
11 Completed Study Analysis Groups (SAGs)

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

SIG 2 – Exoplanet Demographics

- Leadership: Christiansen & Meyer (ExoPAG EC) + 3 community members

- Motivation: Exoplanet demographics reveal planet formation, migration and evolution processes, and are key to predicting the yields of future missions.

- Goal: To augment the Kepler-centric demographics of SAG13 to ultimately provide quantified, independent yield comparisons for 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

	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	

Time	Session	Speaker	
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 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.