

Charter of the TESS Follow-up Observing Program Working Group

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Goal

The primary goal of the TESS Follow-up Observing Program (TFOP) Working Group (WG) is to provide follow-up observations that will facilitate achievement of the Level One Science Requirement to measure masses for 50 transiting planets smaller than 4 Earth radii.

A secondary goal of the TFOP WG is to foster communication and coordination both within the TESS Science Team and with the community at large in order to minimize wasteful duplication of observations and analysis. We operate under the guiding principle that efficient use of limited resources and increased opportunity for collaboration should improve the quality *and* quantity of scientific output. Although the primary focus of the TFOP WG is to achieve the Level One Science Requirements, any science coming out of TESS can also be served.

Scientific Context

The TESS Science Office (TSO) is responsible for producing lists of TESS Objects of Interest (TOIs), based on the light curves, data validation reports, and other mission data products delivered by the Science Processing Operations Center (SPOC) and on other mission resources such as the TESS Input Catalog or Quick Look Pipeline.

After lists of TOIs have been produced by the TSO, the next steps are to identify those TOIs that are astrophysical false positives and to validate surviving TOIs as transiting planets at a high level of confidence so that they can be considered as candidates for additional follow-up observations, such as precise radial velocity work aimed at deriving orbits and planetary masses in order to meet the TESS Level One Science Requirement.

In many cases follow-up observations will also be needed to improve the knowledge of the mass and radius of the host stars, if the uncertainties in those parameters limit the accuracy of the mass and radius of the orbiting planet(s). Follow-up observations may also be needed to improve the knowledge of the contamination of the TESS photometry by nearby objects in the photometric aperture, so that the uncertainty in the contamination does not limit the accuracy of the planetary radius. Although this work will often support follow-up spectroscopy of exoplanetary atmospheres, that effort is the responsibility of the Atmospheric Characterization WG.

TFOP WG Functionalities and Sub Groups

Much of the work of the TFOP WG falls into five general areas of functionality, each of which will have its own Sub Group;

1. Seeing-limited Photometry to identify false positives due to variable stars such as eclipsing binaries that contaminate the TESS image of a candidate transiting planet. The usual procedure will be to schedule observations of predicted transit events to see if nearby objects show eclipses that are responsible for the transit-like events in the target light curves due to contamination. In some cases seeing-limited photometry may contribute to the validation of a candidate by providing a better inventory and better photometry of the objects in the nearby scene to a candidate than is provided by the TESS Input Catalog. For some planet candidates that show deeper transits, ground-based seeing-limited photometry may be able to confirm and/or improve the photometric ephemerides provided by TESS, or even provide improved transit event light curves or transit time variation measurements.
2. Recon Spectroscopy to identify astrophysical false positives and to contribute to improved stellar parameters for the host star in those cases where the uncertainty in the planetary mass and radius is limited by the uncertainties in the mass and radius of the host star. Recon spectroscopy can identify eclipsing binaries that masquerade as transiting planets by revealing large velocity variations due to an orbiting stellar companion consistent with the photometric ephemeris from TESS. Blends of a target star with a nearby (usually fainter) eclipsing binary that is not spatially resolved can show composite spectra where the orbit of the contaminating eclipsing binary is consistent with the photometric ephemeris from TESS. These are but two examples of the false positives revealed by Recon Spectroscopy. Spectroscopic determinations of effective temperature, surface gravity, and metallicity can often contribute to improved estimates of the mass and radius of the host star, when analyzed with the help of stellar models or empirical relations. The Spectroscopic Steering Committee (see below) will help coordinate activities in Sub Groups 2 and 4.
3. High-resolution Imaging with adaptive optics, speckle imaging, and/or lucky imaging to detect nearby objects that are not resolved in the TESS Input Catalog or by Seeing-limited Photometry. This can be important for improving the validation of planets before they are sent on for Precise Radial Velocity observations, or when there is significant light from a very close companion that is contaminating the planetary radius determination.
4. Precise Radial Velocity Work with the goal of deriving orbits for the planet(s) orbiting the host star for the determination of planetary mass(es) relative to the host star. Recon spectroscopy can play a significant role in the selection of the best transiting planet candidates for mass determinations by providing measurements of the line broadening and of activity indicators such as emission in the Ca II and H α lines. The Spectroscopic Steering Committee (see below) will help coordinate activities in Sub Groups 2 and 4.
5. Space-based Photometry with facilities such as HST, Spitzer, MOST, CHEOPS, and JWST, primarily to confirm and/or improve the photometric ephemerides provided by TESS, but also to provide improved light curves for transit events or even transit time variations in some cases.

Organization

The TFOP Working Group Steering Committee

The Steering Committee for the TFOP WG shall consist of the chairs for the above five Sub Groups plus the TESS Director of Science and Deputy Director of Science, and a representative for ExoFOP-TESS at NExScI. Initially the subgroup chairs shall be Karen A. Collins for Seeing-limited Imaging, Samuel N. Quinn for Recon Spectroscopy, David Ciardi for High-resolution Imaging, David W. Latham for Precise Radial Velocity Work, and Diana Dragomir for Space-based Photometry. The current Director and Deputy Director of Science are David W. Latham and Sara Seager. Jessie Christiansen is the current representative for ExoFOP-TESS at NExScI.

The Sub Group chairs are responsible for organizing the activities of their Sub Groups and recruiting the initial members. People who wish to become a member of the TFOP WG should approach the chair of the Sub Group in which he or she is most interested. Sub Groups can choose to operate under this general charter, or they may choose to develop their own charter that governs the organization of their Sub Group. Individuals may be members of more than one Sub Group.

The Spectroscopic Steering Committee (SpecSC)

The role of the SpecSC is to coordinate the spectroscopic follow-up observations

1. The SpecSC will meet (e.g., via WebEx or Zoom) regularly to discuss which targets appeal to each team, and to decide how targets should be coordinated -- or on which targets collaboration (or even duplication) would make sense. This will be somewhat fluid initially, as it will sometimes depend on the results of SG1, SG2, or SG3 observations. The SpecSC will meet approximately once a month, or in some cases soon after large releases of new TOIs. In the latter case, the SpecSC should decide how long after a TOI release they want to meet (e.g., to allow time to evaluate targets and perform initial follow-up). Other considerations might include upcoming long observing runs for classically scheduled telescope time.

Although ExoFOP-TESS is to be the main repository of follow-up information, the SG2/SG4 observation coordinator (Google sheet) will still be used to indicate interest in particular systems -- this can guide target selection discussions during meetings. The other members of the SpecSC should be the first resource to help find agreeable solutions as needed. Some situations may call for parallel papers.

2. The SpecSC will discuss progress of observations and analysis, especially if more than 1 team is involved in the effort.

Who sits on the SpecSC?

Anybody who is interested can ask to join the SpecSC, though **1 representative per team** would keep the group small enough to have productive discussions. (Some teams may have complicated structures involving multiple facilities, in which case nominating more than 1 representative could make sense. In other situations, 1 person might be able to represent more than 1 team.)

PIs/team leaders should nominate a member of their group (representatives do not need to be PIs/team leaders). Other TFOP WG members are welcome to self-nominate if a case can be made that it makes sense for them to join the SpecSC. Nominees should indicate which spectroscopic Sub Group(s) they are associated with and which team(s) (if any) they are representing, and nominations should be sent to the SG2 and SG4 chairs (currently Dave Latham and Sam Quinn).

SpecSC representatives may come from teams with PRV resources or teams with access only to facilities that are not as precise (a few to tens of m/s), but are still able to measure orbits of large planets. While TFOP aims first to support Level 1 science ($R_p < 4 R_e$), most of us are also interested in other topics and the SpecSC can help organize these efforts in the same way as the small planet effort. Coordinating when TOIs are first released, and as the first few RVs are obtained, will cut down on duplication and assure that everybody has appropriate opportunities to lead and contribute to these papers.

Joining SpecSC calls

While representatives to the SpecSC should be kept to a minimum for practical purposes, any TFOP WG member should feel welcome to listen in to SpecSC calls, particularly when discussions include systems on which that member is already working, or perhaps to provide clarification for discussion if their SpecSC representative is not fully versed in their science case. If a representative is unable to attend a meeting, another TFOP member can be designated as a stand-in representative.

Conduct and Working Group Policies

Joining the TFOP WG is considered a statement of intention to abide by the conduct and policies set forth herein, and to contribute to the tasks outlined above.

Collaboration and coordination – both within the TESS Science Team and with the greater community – will be paramount to the success of the TFOP WG and the TESS mission. TFOP WG members will therefore make good faith efforts to coordinate the planning of observations and to share TOI-related data and results by uploading to ExoFOP-TESS in a timely manner. Members further agree to protect all intellectual property shared at meetings (in person, or via phone/video) or on the web and through email.

In some cases the data and results obtained by TFOP WG members may have restrictions that prevent uploading to a website available to the open public. One example might be

products from collaborations or institutions where there are prior agreements that constrain open public release until certain conditions (such as publication) are met. Another example might be preliminary results from Precise Radial Velocity Work, where data need to be accumulated until a definitive orbit can be derived. Members of the TFOP WG have the option of declaring a proprietary period of up to one year for any observations or results that they upload to ExoFOP-TESS. Such proprietary information is then viewable only by other members of the TFOP WG until the expiration of the proprietary period, at which time the information becomes public.

To facilitate collaboration and scientific output, TFOP WG members should propose to lead projects that make use of TFOP data. These proposed projects will be listed securely on the membership pages of the TESS wiki, and should be interpreted as signaled intent to lead a project (rather than proprietary ownership of it). These proposals will enable the solicitation of additional data and will foster connections with other group members who have the interest and expertise to contribute. They will also reduce the number of duplicative efforts (and the rush to publish, which often lowers quality), and they will provide the originators of data the opportunity to be asked to join collaborations on projects that rely upon their data.

If observations submitted to EXOFOP-TESS are useful in improving the confirmation and characterization of planets, then the person who provided the observations should be granted the right of co-authorship on the first paper that reports and utilizes these observations. TFOP WG members who want to utilize data obtained by others should contact the originator of the data so that the involved parties can decide whether authorship is warranted or instead an acknowledgement is sufficient. In this way, TFOP WG members who provide valuable reconnaissance observations that might not always lead to their own publications can get appropriate recognition for their contributions. For further details, consult the Publication Page on the TESS Wiki, the TFOP WG Publication Policy, and the TESS Mission Publication Policy

Concerns about collaboration and data usage can be brought to the TFOP WG Steering Committee, who can mediate any disputes if necessary.

Collaboration with non-TFOP colleagues

Many TFOP members will have colleagues who are not TFOP members. Sometimes we will publish papers with them, and even without any impropriety on the part of TFOP members (i.e., no information disclosed in either direction about existence of or details about competing papers), sometimes other TFOP members will be working on similar papers. Rather than imposing restrictions about outside collaboration, we prefer to trust our colleagues to act appropriately in these situations. However, we believe the following guidelines can help TFOP members navigate potentially difficult situations, while remaining true to the TFOP commitment to open communication.

In the event that a TFOP member is asked to participate in a paper led by a non-TFOP colleague, they are free to do so, remembering that they are not allowed to reveal

information about the existence of, or details about, a competing TFOP publication. The TFOP member should:

1. Encourage the outside collaborator(s) to join TFOP, with the understanding that if there is a competing paper within TFOP, the outside collaborators will have to negotiate a collaboration or coordinated submission of papers.
2. If the first option is rebuffed, and there *is* a competing TFOP paper, or the TFOP member later learns of one, the TFOP member should wait to see which paper nears completion first. If the outside group nears completion first, the TFOP member should ask the outside group if they would be willing to reach out to the TFOP group to coordinate submission. If the TFOP group nears completion first, the TFOP member should not say anything to the outside group; they were already offered the chance to collaborate or coordinate. This strategy does not tip off either group unfairly, and is in accordance with members' commitments to the TFOP effort.

Communications and Membership

TFOP WG communications utilize mailing lists for the full Working Group, the Sub Groups, and the SpecSC as appropriate. All emails to the mailing lists should be treated as confidential and should never be forwarded or copied to non-members. Regular meetings, held electronically via WebEx, will occur to discuss the planning, status, and analysis of observations. Additional suggested topics of discussion or concerns should be directed to the appropriate Sub Group chairs and will be reviewed by the Steering Committee as needed. Individuals with the desire and ability to contribute to the TFOP WG can apply to become a TFOP WG member. Applications should be sent to the chair(s) of the appropriate Sub Group(s) and will be reviewed by the Steering Committee. Applications must contain:

- A statement that the applicant agrees to abide by the TFOP WG charter.
- A summary of the applicant's scientific background, research interest and expertise, and expected/planned contribution to the TFOP WG,
- The facilities available to the applicant for follow-up work, and the Sub Group(s) of interest.

Members of any subgroup may participate in meetings and communications of any other subgroup, but without voting privileges.

Efforts to carry out atmospheric characterization of TESS planet candidates can have long lead times, and it may be desirable for such efforts to be started prior to the publication of said TESS planet candidates. In such cases, access to TFOP WG data may be beneficial. Individuals interested in atmospheric characterization of TESS planet candidates who wish to use proprietary TFOP data for proposal preparation purposes may apply to join the TFOP WG. Such individuals are not required to contribute observing resources, but they must first join the TESS Atmospheric Characterization Working Group (ACWG). ACWG applications should be submitted to the ACWG's lead, currently Drake Deming. TFOP members exclusively interested in atmospheric

characterization do not need to belong to any TFOP Sub Group, but will be granted access to the TFOP protected section of ExoFOP-TESS if they apply to become a member of the TFOP WG and agree to abide by the TFOP WG Charter and Publication Policy

If there are scientists who would like access to the TFOP WG protected section on ExoFOP-TESS in order to enable better science (both exoplanet science and non-exoplanet science), they can make their case in an application to join the TFOP WG, submitted through Dave Latham for review by the TFOP WG Steering Committee. Here again they must agree to abide by the TFOP WG Charter and Publication Policy if their application is approved.

An approved member of the TFOP WG may include more junior scientists as part of his/her research group without the junior scientists having to apply to be members. In this scenario, the approved member is responsible for the conduct and behavior of the junior members with whom he/she is associated, and the junior members are bound by the same conduct and behavior rules as the approved member. A junior member may apply to be a member of the TFOPWG on his/her own; such an application is subject to the same approval process as any other application.

Junior scientists who are sponsored by their team leader need to join as a formal member of the TFOP WG if they plan to lead a paper.