

ExoTAC Report on Starshade S5 Milestone #2 Review

September 20, 2022

A telecon review of the Milestone #2 Final Report for the Starshade Technology to TRL 5 Activity (S5) was held on September 20, 2022. With one exception (Joe Pitman, who had another commitment), all of the ExoTAC members were able to participate in the telecon. Milestone #2 deals with model validation, i.e., being able to theoretically predict the effect on high contrast of perturbations to the starshade's physical structure from the ideal configuration. The reworded MS #2 objective is:

“Small-scale starshade masks in the Princeton Testbed validate contrast vs. shape model to within 25% accuracy for petal shape and 100% for petal position for induced contrasts between 10^{-9} and 10^{-8} .”

The Princeton Testbed was used for the experiments, the same as used successfully for Milestones #1A and #1B, with the addition of a linear polarizer in the laser light source, in order to constrain the effects of vector diffraction. Vector diffraction was the reason for the rewording of MS#2, but is known to be a negligible effect for a flight scale starshade, with a diameter roughly 1000 times larger. Six different masks were used to test the effects of displaced petal edges, radially outward shifted petals, combinations of these perturbations, and sine wave edge perturbations. 156 different combination of perturbations, wavelengths, and mask angular orientation were tested and compared to the models. The optical models employed both scalar and vector diffraction propagators. Several different methods for calculating scalar diffraction were examined and found to agree to contrast levels better than $1e-11$. Table 6 presents a summary of the results, showing that the vector diffraction model is accurate to within about 5% accuracy for petal shape and to within about 100% for petal position, thereby meeting the objectives for MS #2. Many details of the Princeton Testbed investigations have been published as SPIE papers and are included as appendices. The Final Report presents error budgets, based on these results, for both a 26-m diameter starshade rendezvous mission (SRM) with the 2.4-m Roman Space Telescope and for a 64-m diameter starshade coupled with the 6-m space telescope called for by the Astro 2020 Decadal. The error budgets conclude that SRM would achieve a total instrument contrast of $1e-10$, while the Decadal starshade would conservatively achieve a contrast of $5e-11$, at least a factor of two better.

The ExoTAC raised a number of questions during the review, all of which were answered satisfactorily by Stuart Shaklan, the primary speaker. The ExoTAC believes that *Milestone #2 has been fully met* and congratulates the entire team on their excellent efforts to advance the technology readiness levels of the elements in the S5 activity.

We thank Anthony Harness for performing the work and Stuart Shaklan and Doug Lisman for their presentations and comments during the review.

Exoplanet Exploration Program TAC Members

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