ExoTAC Report on Starshade S5 Milestone #7A Review

April 17, 2020

A telecon review of the Milestone #7A Final Report for the Starshade Technology to TRL 5 Activity (S5) was held on April 15, 2020. With one exception (RO), all of the ExoTAC members were able to participate in the telecon.

Milestone #7A deals with the thermal stability of the mechanical structure that forms the outer ring of the inner disk subsystem (IDS), to which the starshade petals are attached. This structure consists of longerons that are attached at each end to nodes, forming a single perimeter truss bay. The Milestone #7A objective is to demonstrate that the critical dimensions of the longerons and nodes remains consistent with the pre-launch accuracy of +/- 300 microns during thermal cycling after deployment on orbit. This Milestone accuracy is consistent with the overall contrast goal of 1e-12 that is assigned to the total petal position errors for KPP7. Milestones 7B, 7C, and 7D will contribute further errors to the total petal position accuracy.

The test articles were subjected to 50 thermal cycles (from 70 C to -25 C), more than enough to be consistent with the expected on-orbit science mode environments of the Starshade Rendezvous Mission (SRM). The deleterious effects of ground test and flight mode thermal cycles were not the subject of this TRL5 effort. For Milestone 7A, the longerons and nodes will not be attached to a truss during the testing; Milestone 7B will test both deployed and stowed configurations. Full-scale SRM test articles of flight-like materials were tested on the MicroVu Excel measuring machine before, during, and after thermal cycling in the CSZ and SPX environmental chambers. MicroVu has a repeatability accuracy of 5.5 microns. The largest thermal cycle distortions measured for longerons and nodes were 27 microns and 25 microns, respectively, well within the target allocations of 68 microns, thereby formally meeting the Milestone 7A requirements. Moisture absorption at the San Diego facility by the CFRP longerons and Cyanate Ester epoxy bonds is a likely significant cause of the 19-micron length distortion for one of the longerons. The node distortion of 17 microns may have been caused by debonding or local damage after a thermal soak.

The ExoTAC raised concerns during the review on several issues:

1) The thermal range tested is far less severe than the flight article can be expected to experience during spacecraft qualification testing prior to launch and during launch itself. The need for addressing those effects on dimensional stability for these much larger magnitude of temperature changes or quantity of thermal cycles needs to be highlighted as a future concern in the Final Report.

2) It would be useful to include an Invar “meter stick” when using the MicroVu Excel machine in order to improve the calibration procedure.

3) Variations in the truss bay length around the circumference may be both random and systematic. The current error budget assumes only random errors are significant. Systematic effects may be approximately uniform (e.g., thermal effects dependent on solar altitude above the starshade plane) or non-uniform (e.g., thermal effects dependent on solar azimuth during starshade rotation) and may lead to an overall bias rather than random distortions that average out. If so that error needs to be estimated and included in error budget during future development activities. While expected to be small, these types of variations should be monitored as development of the rest of the spacecraft proceeds, as spacecraft bus shadowing is a major cause of non-uniform illumination.

In summary, the ExoTAC believes that Milestone #7A as written has been met and congratulates the entire team on their efforts to advance the technology readiness levels of the elements in the S5 activity.

We thank Manan Arya, David Webb, Flora Mechentel, Doug Lisman, and the other S5 team members for their presentations and comments during the review.

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