WFIRST Coronagraph TAC Report on Milestones #8 & #9 Review

November 10, 2016

A Webex review of Milestones #8 & #9 for the WFIRST coronagraph technology program was held on November 8, 2016. All five of the TAC members were able to participate in the review. The preliminary results for both Milestones were delivered to the TAC on October 3, meeting the planned due date of September 30, 2016. Updated results were delivered to the TAC shortly before the start of the review on November 8. This date was chosen in order to meet the schedules of the TAC members and the WFIRST-C team members. This slight delay allowed further testing to be performed, resulting in improved performance on both Milestones.

Milestones #8 and #9 dealt with the OMC (SPC and HLC) and PIAACMC coronagraph tests in the JPL HCIT, in both static (PIAACMC) and dynamic (OMC) environments, the latter simulating the expected performance on a space telescope with pointing jitter.

Milestone #8 was intended to demonstrate 10^{-8} raw contrast with 10% broadband light at 550 nm in a static environment, as well as to characterize the sensitivity of the PIAACMC to pointing and focus. Initially, the raw contrast achieved was only $\sim 10^{-6}$ raw contrast in broadband, but in the updated report the contrast improved to 1.8×10^{-7} in broadband, showing significant improvement, but still short of the formal Milestone. The PIAACMC contrast is expected to improve if further effort is devoted to its development; the main limitations appear to be the shortage of time in the HCIT and a need for jitter suppression at the entrance pupil. Progress was also made in determining the sensitivity of PIAACMC to WFEs for low-order Zernike distortions in monochromatic light. The TAC agrees that the raw contrast requirement of Milestone #8 has not been met, but supports further efforts with PIAACMC, given the possibility of better science performance with a smaller IWA and higher throughput with PIAACMC, compared to the OMC. It is also important to note that this is the first PIAACMC with a WFIRST-type occulter, and as such represents a significant technology advance.

Milestone #9 was planned to demonstrate 10^{-8} raw contrast with 10% broadband light at 550 nm in a dynamic environment. Initially, the raw contrast achieved was only 2.8×10^{-8} in broadband, unmodulated light, with the OMC GSE (ground support equipment) being a major source of the unmodulated light. In the updated report, the contrast improved to 9.15×10^{-9} static raw contrast for the SPC in 10% broadband light, once the OMC ground support equipment was improved to reduce the unmodulated residual light. The HLC achieved nearly the same static raw contrast, namely 1.16×10^{-8}. The HLC is currently running in the HCIT and may very well improve its contrast performance.

However, it must be noted these quoted contrasts for Milestone #9 were obtained through static testing in the HCIT. Modeling of the expected degradation in a dynamic environment was also performed, but the contrast measurements were not performed simultaneously with the dynamic jitter. This crucial point was not made clear in the presentation, but was caught and called out by one TAC member in the final minutes of the telecon. Hence the TAC concludes that in a strict sense, the requirement of Milestone #9 for contrast in a dynamic environment has not been met. Nevertheless, the team has shown that all the required functionalities for performing true simultaneous testing of Milestone #9 (i.e., the major improvements to the OMC GSE) are now operational. The TAC encourages the team to continue their efforts with both the SPC and the HLC in the dynamic testing environment to enable Milestone #9 to be truly achieved for either, or both, methods. The TAC would be willing to review a re-revised Milestone #9 report in the future, once sufficient further HCIT time has allowed the Milestone to be achieved.

The project has finished seven of the nine WFIRST coronagraph Key Milestones on schedule. The TAC looks forward to learning about the successful completion of Milestone #9 in the near future. The inability of the team to meet Milestone #8 in the time available to date does not detract from the overall success of the coronagraphic technology development effort, as the PIAACMC approach was designated as a backup technology, with the OMC being the primary candidate for flight. Finally, the TAC and the team agreed that polarization effects might limit contrast achieved for all three architectures and that this needs to be explored in more detail experimentally in the testbeds.

We thank all of the WFIRST-C team members for their presentations and comments during the review.

WFIRST Coronagraph TAC Members

Alan Boss (Chair), Carnegie Institution

Rebecca Oppenheimer, American Museum of Natural History

Joe Pitman, The Sensing Company

Lisa Poyneer, Lawrence Livermore National Laboratory

Steve Ridgway, National Optical Astronomy Observatory

Detailed comments from Joe Pitman:

The MS 9 work is hugely impressive to me and largely a success. Although they attribute shortfalls to the star and COTS pinhole used, I'm both agreeing their lithographed better pinhole will help while I'm skeptical that polarimetric effects are fully understood to the level needed for flight instrument implementation. I asked and listened but am not convinced they've isolated it to the source star characteristics. I also think the actual AFTA front end OTA for this application, as opposed to its original application, will be a bigger source of polarization effects so felt they need time to work this aspect. Also, as Lisa and I each addressed during the telecon, crosstalk between LO and HO control needs to be a point addressed during work forward. I'm glad Dave feels CGI isn't a driver or a victim of Obs optical quality but will feel better when a bit more is looked at for CGI sensitivity to Obs error budgets, as a complement to those for Testbed error budget.

Detailed comments from Lisa Poyneer:

Discussion during the review has highlighted several areas that could be explored more fully in future work. These include:

1) Assessment of the robustness of the simultaneous control of DM1 by both the LOWFS and HOWFS
2) Assessment of the robustness of the LOWFS LoS LMS controller to model uncertainties in a more flight-like environment.
3) Calibration of the LOWFS reconstruction with both SPC and HLC "dark hole" voltages on DM1
4) Analysis that Monte Carlo testing for model validation is correctly sampling the phase space in producing performance estimates and bounds.