Optical Alignment and Tuning of Multiview Onboard Computational Imager (MOCI) 6U CubeSat Optical Payload

Multiview Onboard Computational Imager Satellite (MOCI Sat) – University Nanosat Program 9 – AFRL
Charles Jackson Bradford[*1] , Deepak Mishra[+1]
*Charles.bradford@uga.edu, +dmishra@uga.edu, [1]Small Satellite Research Laboratory, University of Georgia

Overview

As the University of Georgia's Small Satellite Research Laboratory (SSRL) moves toward launch with the Multiview Onboard Computational Imager mission (MOCI), started in 2017, one of the final steps before full integration is to confirm the flight readiness of the optical payload. MOCI has an optical payload developed by RUDA Inc. consisting of a ten-lens system, one monochromatic sensor (IMPERX Cheetah C4180), and one Forward Looking Infrared (FLIR) sensor (TeleDyne FLIR Blackfly S). To confirm flight readiness for the optical payload, Modulation Transfer Function (MTF) testing must be performed on a series of images taken by the optical system. MTF testing is an optical industry standard, and the corresponding results are a holistic measure of the quality of an image taken by an optical system. In addition to MTF, Slanted-Edge MTF testing is performed to confirm the optical alignment of the lenses within the payload by having the imager photograph a slanted target plate with a known tilt and compute the relative tilt of an edge as seen from the optical system. All MTF testing was ran within Matlab utilizing open-source MTF testing software.

Upon initial testing at the RUDA Inc. facility, the optical system recorded MTF values greater than 0.55, however, final testing at the SSRL is needed to confirm the payload's flight readiness. After discussion with RUDA Inc. it was determined that images with MTF values greater than 0.3 and with a calculated slant-edge of ±0.2° from the known slant angle would confirm the optical payload's flight readiness. While an optical system is normally considered flight ready with confirmed MTF values greater than 0.5, it was determined that due to the lab's limited testing hardware, MTF values greater than 0.3 would suffice as preflight confirmation.

Procedure

To test the optical payloads final resolution and compute MTF values, the system was placed upon an optical test bed within the SSRL clean room and placed on mounts, facing a target plate, with a collimator set between the optical payload and the target plate, as seen in **Figure 1**.

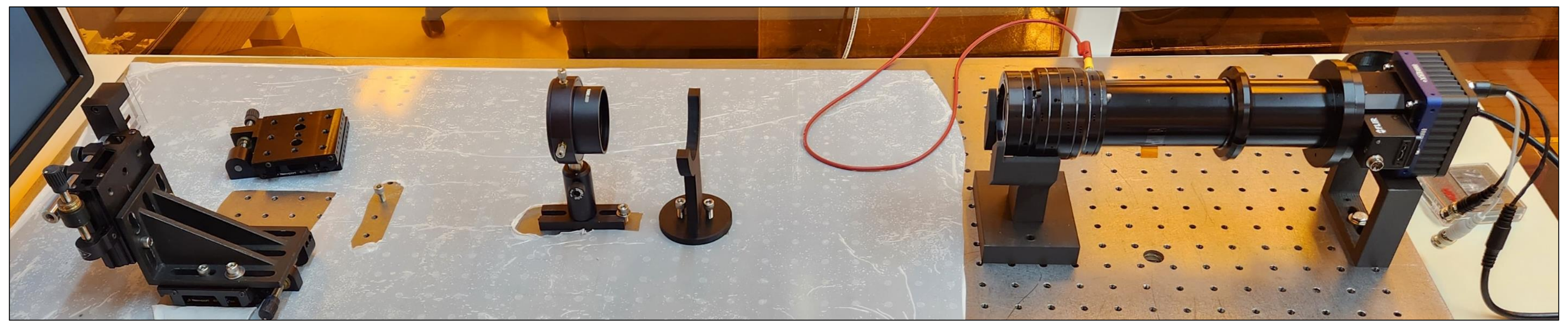

Figure 1 : The optical testing set up within the SSRL cleanroom

Once the optical system had been placed in the testing configuration, the collimator was set to an infinite conjugate setting. In setting the collimator to this infinite conjugate setting, it was brought into alignment with the exact focal point of the optical system. This enabled the optical system to clearly see the target plate and ensured accurate MTF testing. After setting the collimator to the infinite conjugate setting, a series of images were taken at different points on the target plate to ensure holistic readiness of the optical system. Each image was then analyzed within Matlab by sampling an edge close to the optical system's center of focus. From their, all MTF values were calculated, and adjustments were made to the collimator and optical system to refine and improve our experimental values.

Results

MTF values and areas of focus are identified in **Figure 2**. Along the left side and bottom portion of the imaging target, MTF values of 0.377 and 0.330 were recorded at 57 lp/mm, with a calculated angle between 5.01 and 5.1 degrees. However, upon further analysis across varying areas of the target plate, MTF values dropped to as low as 0.247 with no considerable change in relative angle. Areas of lower MTF were identified along the right portion of the target plate with MTF ranging from 0.304 to 0.247 in these areas. Across central portions of the target plate, MTF values again climbed to ranges between 0.302 to 0.338 with no considerable changes in relative angle.

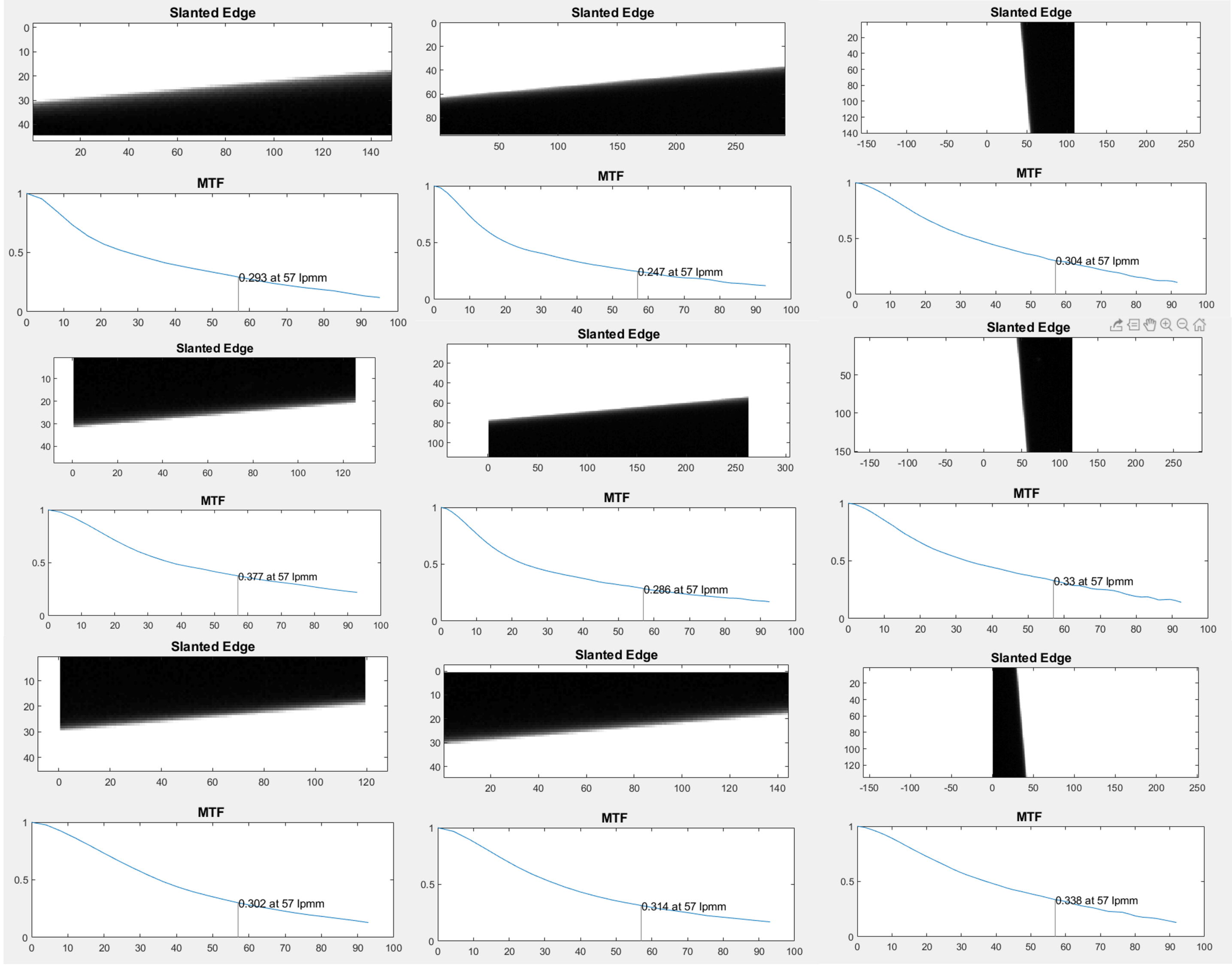

Figure 2 : Areas of focus and corresponding MTF charts measured at 57 lp/mm

Conclusion

With the initial values received from the optical system and the consistency of the system's relative angle measurement, the optical system shows promise as the final stages for flight approval are addressed. However, the results suggested that errors had been introduced within the testing procedure. It is believed that a misalignment within the manual transfer stages led to the proceeding drop in MTF values as the target plate was transferred from left to right during testing and thus minutely out of the optimal focal plane. This research suggests that final adjustments must be made to the manual transfer stages to account for this misalignment.

Next steps involve approval of MTF values from RUDA Inc. and the University Nanosatellite Program. From there the optical system will undergo final modification to install the vacuum shims, specialized shims to eliminate differences between testing on earth and in vacuum, and final integration within MOCI.

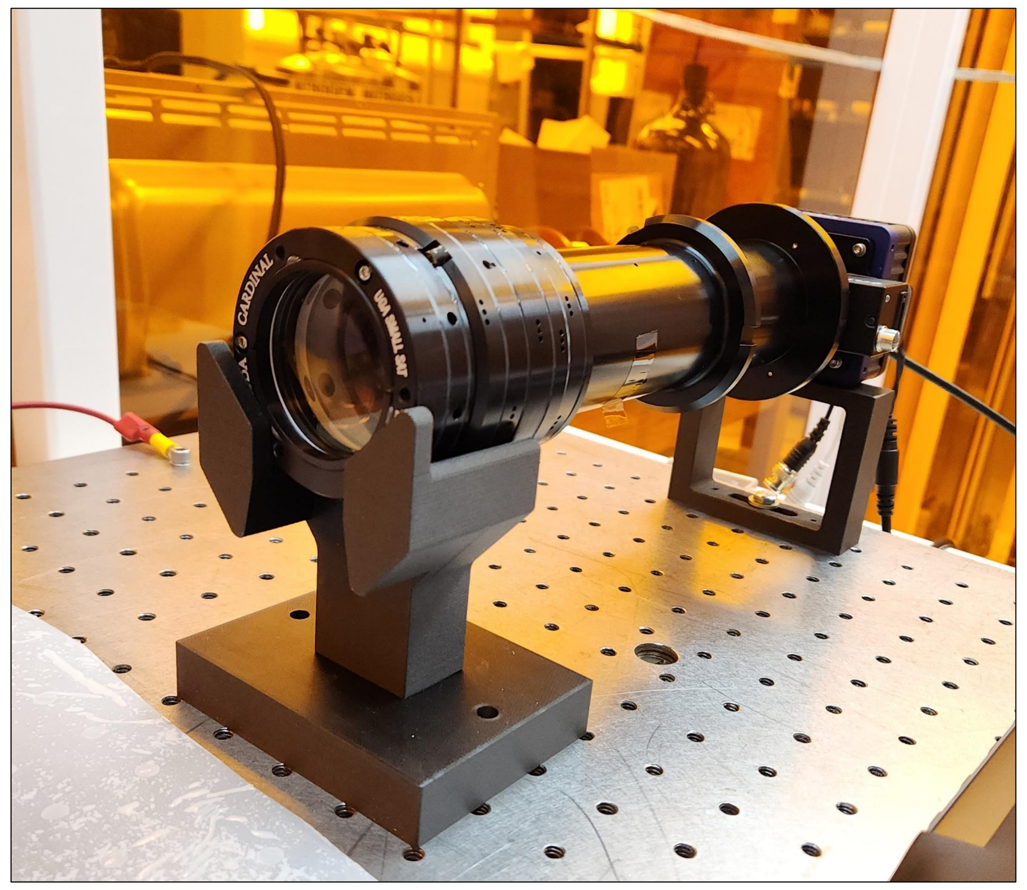

Figure 3 : Photo of optical system during final testing

Small Satellite Research Laboratory
Franklin College of Arts and Sciences
UNIVERSITY OF GEORGIA

2023 UGA CURO Symposium
Athens, GA April 3-4

Center for Undergraduate Research Opportunities
UNIVERSITY OF GEORGIA