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# PROTOTYPING AND TESTING OF THE HIGH-RESOLUTION OPTICAL PAYLOAD FOR THE SPUDNIK-1 CUBESAT

Khiym MacEwen, Grant McSorley*
Faculty of Sustainable Design Engineering, University of Prince Edward Island, Charlottetown, Canada
*gmcsorley@upei.ca

## ABSTRACT

SpudNik-1 is a remote sensing CubeSat designed to collect visual band imagery of Prince Edward Island for precision agriculture applications. The imaging payload is a Ritchey-Chrétien style optical system with additional 45-degree mirrors to fold the optical path, thereby achieving increased resolution in a reduced volume. To validate the design, characterizing expected image quality is crucial. This work presents the results of prototyping, testing and design refinement, as well as lessons learned for CubeSat design in an undergraduate context.

A prototype of the current detailed design was manufactured using a combination of 3D printing and machining, which allowed for rapid iteration. Detailed inspection plans mitigated the risk of dimensional errors. Both benchtop and long distance imaging tests were performed.

Benchtop tests included a resolution test using a 1951-USAF resolution test chart. A halogen point light source was used, and the light was collimated using an expanding lens followed by a Fresnel lens. Precision translation stages ensured accurate positioning. Resulting images were analyzed to determine the line pair resolution. Long distance imaging was completed from the roof of the engineering building focusing on contrasting, sharp edged objects approximately 1 km away. An extension was installed on the payload to reduce stray light entering the aperture.

For both testing scenarios, the prototype design facilitated repositioning of the image sensor along the optical path and switching between folded and straight optical paths. In this way, multiple factors impacting image quality could be investigated independently or in combination.

MATLAB was used to characterize image quality using spatial frequency response (SFR). SFR describes how the contrast changes as a function of spatial frequency for an optical system. This is done on a high contrast, slanted edge, such as a dark window on a light-colored building. Once established across various scenes, this will be compared against future modifications to verify improvement. This can also be done on the test chart images captured on the test bench for comparison.

While adjusting the sensor position changes defocus, the next steps include a modified setup permitting the adjustment of the relative positions of the primary and secondary mirrors and evaluating the impact on image quality. Results include the characterization of the imaging system, confirmation of critical dimensions and tolerances, an updated detailed design package, and a final prototype reflecting the flight ready design.