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Author: Mr. Craig Ingram
Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia

Dr. Joshua Pease
Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia
Dr. Stephen Gensemer
Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia

# EXPANDING HORIZONS IN LEO EARTH OBSERVATION: A NOVEL FREEFORM WIDE FOV REFLECTIVE TELESCOPE DESIGN INCORPORATING FREEFORM SURFACES AND INTEGRATED MIRROR SYSTEMS

**Abstract**

Wide field-of-view (FOV) imaging holds significant promise for enhancing the capabilities of low Earth orbit (LEO) Earth observation satellites by providing extensive global coverage. Reflective designs, preferred for their elimination of chromatic aberrations across the broad wavelength spectrum required for modern Earth observation (EO) missions, often face limitations in FOV. This paper introduces an innovative approach using an all-reflective off-axis Three Mirror Anastigmatic (TMA) telescope system, incorporating a freeform primary mirror and an integrated tertiary mirror. This design aims to maximize FOV, maintain diffraction-limited performance, and minimize system dimensions while simplifying the assembly and alignment processes.

In this paper, we present a novel freeform wide field-of-view reflective telescope, starting from the optical design, and continuing to tolerancing analysis and manufacture, towards a proof-of-concept demonstrator. The proposed telescope system is particularly noteworthy for achieving a 15 x 7.5 degree full FOV, resulting in a swath width of approximately 100 km at a nominal altitude of 584 km. The utilization of a freeform surfaces with off-axis mirrors offers additional degrees of freedom, empowering the optical design to correct higher-order distortions across the field. Despite the inherent complexity associated with TMA telescopes, the integration of a freeform primary mirror and an integrated tertiary mirror addresses issues related to FOV limitations and bulkiness.

This work builds upon the success of CyanoSat, a 3U hyperspectral imager based on a TMA, launched in Q2 2023. The authors present a detailed optical design and tolerance analysis of the proposed telescope system, positioning it as a proof of concept lab demonstrator. This advancement is seen as a significant stride in the realm of Australian space missions, promising improved Earth observation capabilities and contributing to the enhancement of Australian manufacturing in the space technology domain.