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USING DESIGN FLEXIBILITY TO MEET CHANGING OPERATIONAL NEEDS: A SMALL
SATELLITE MISSION EXPERIENCE REPORT

Abstract

Sapphire is a Canadian small satellite mission for the surveillance of space. Since 2013, the system has been a certified contributing sensor to the Space Surveillance Network (SSN) and continues to play a vital role in tracking deep space objects for enhanced Space Situational Awareness (SSA). MDA was the mission Prime Contractor for the Canadian Department of National Defence (DND) customer during Sapphire development, and currently operates the system under contract to the DND. With over four years of in-orbit experience, Sapphire has continued to evolve in response to changing environmental conditions and modified mission objectives. This paper describes how MDA and the DND have collaborated to adapt the system and its operational approach over time by taking advantage of flexibility built into the design.

The paper describes a number of operational scenarios from the mission. For each scenario, the operational challenge is elaborated along with the design adaptation used to enhance performance and address the challenge.

These scenarios include the following: a) The use of in-orbit annealing operations to heal radiation damage in the detector to reduce dark current noise and improve image quality performance; b) The use of background sky images to calibrate the camera geometric distortion and improve observation accuracy performance; c) The seasonal tuning of the sensor Field of Regard in order to optimize satellite equipment operating temperatures; d) The modification and configuration of camera Exclusion Zones to make more efficient use of the sensor and reduce the frequency of poor quality images; e) The modification of the system scheduling function to increase task throughput for enhanced observation of objects with Highly Eccentric Orbits (HEOs).

Analysis of the operational challenges and resulting design adaptations yields insight into the type of design flexibility that is beneficial during mission operations. The Sapphire in-orbit experience provides guidance to other small satellite missions regarding the evaluation of system design trade-offs and the rationale for investing in design flexibility.