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STRATHCUBE: THE DESIGN OF A CUBESAT FOR SPACE DEBRIS DETECTION USING IN-ORBIT PASSIVE BISTATIC RADAR

Abstract

There is a growing need to detect, track and catalogue space debris in the congested LEO region. Current ground-based radar or optical technology is insufficient to track debris smaller than 10cm, meaning that millions of estimated pieces go undetected. A method to detect debris more effectively is to use space-based passive bistatic radar (PBR). This is because of the reduced distance between transmitter and receiver, lower relative velocities of the transmitter and receiver, and the Earth's atmosphere can be bypassed reducing the associated attenuation and errors. The STRATHcube project proposes to launch a CubeSat into LEO as a PBR technology demonstrator where a signal processing algorithm developed at the University of Strathclyde to detect space debris will be tested. The concept involves a radar receiver and antenna on-board a CubeSat orbiting at a low altitude to detect the variations in radio signals transmitted by operational satellites orbiting at higher altitudes, indicating that an object has interrupted the signal.

This paper will present the integration of PBR technology onto a CubeSat as a payload on the STRATHcube mission and discuss the challenges faced due to the limitations of the small platform. The design of STRATHcube has undertaken an iterative process where the payload and supporting subsystems were matured concurrently. The PBR payload design was based on two approaches: one being an off-the-shelf patch antenna and the other being a custom developed 3D phase array antenna with three candidate configurations, each with different values of mass and power. A high-level design for each option was completed to evaluate their capabilities on the size of trackable debris and to determine their mass and power parameters. An extensive trade-off analysis at a system level was then carried out to narrow down the options of the PBR payload on the CubeSat platform. The integration onto a CubeSat presented a challenge as the size, available power, mass and duty cycle of the payload were all limited due to the small platform. The completed design of the STRATHcube mission will enable an in-orbit demonstration of the PBR technology, which if successful will provide an alternative to conventional ground-based tracking that is cheaper and more available to the space community. This method would then be proven to industry who can use this approach to implement on a larger scale in the future.