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Author: Mr. Mayank Mayank
Germany

Mr. Alok Lenka
Germany
Dr. Antonio Pedivellano
DcubeD (Deployables Cubed GmbH), Germany
Mr. Killian Quetel
DcubeD (Deployables Cubed GmbH), Germany
Ms. Laura Schmitz
DcubeD (Deployables Cubed GmbH), Germany
Mr. Jerome Rose
German Orbital Systems GmbH, Germany
Mr. Chirag Singh Mukherjee
German Orbital Systems GmbH, Germany
Mr. Kevin Banea
Blackwave GmbH, Germany
Mr. Joram Gruber
DcubeD (Deployables Cubed GmbH), Germany
Mr. Guillem Quintana Buil
DcubeD (Deployables Cubed GmbH), Germany
Mr. Johannes Schumacher
Germany
Mr. Jeremy Liu
German Orbital Systems GmbH, Germany
Mr. Martin Wantoch von Rekowski
Blackwave GmbH, Germany
Mr. Thomas Sinn
DcubeD (Deployables Cubed GmbH), Germany
Prof. Jaan Praks
Aalto University, Finland

DESIGN AND DEPLOYMENT FEASIBILITY STUDY OF A 3-PANEL REFLECT-ARRAY ANTENNA FOR 12U CUBESAT

Abstract

This paper presents a reflect-array antenna specially crafted for a 12U CubeSat, capitalizing on the advantages of compact storage and heightened directivity performance. The antenna comprises an array of unit cells illuminated by a horn feeding antenna. The study outlines the vital prerequisites, methodology, and initial design analysis of a 3-panel reflect-array antenna developed as part of the MARAS initiative and supported by the ESA ARTES CC program.

Emphasizing the all-encompassing design requirements encompassing RF performance, mechanical assembly, integration, and deployment, the antenna is segmented into three reflector panels. Its objective is to achieve duplex communications within the frequency range of 25.5-27 GHz (downlink) and 29.5-30 GHz (uplink) with wide bandwidth. The paper delves into the exploration of potential RF materials, detailing the criteria for the final antenna design. The presented design methodology addresses the incorporation of phase shift on the flat reflector and examines various unit cell types to meet performance targets. Simulation results and discussions on the analyzed unit cells are included.

The mechanical design of the reflect-array aperture tackles challenges to attain stringent surface accuracy and thermo-elastic stability for Ka-band applications. Envisaging a combination of thin dielectric layers and a state-of-the-art fiber-reinforced structural sandwich, the design delivers thin panels with a high stiffness-to-mass ratio connected by hinges. The deployment mechanism, powered by elastic energy stored in the hinges, enables passive deployment. Shape memory alloy actuators offer a simple, reliable solution to secure the panels during launch and trigger their deployment in space. The paper provides insights into deployment dynamics through rigid body dynamics and flexible dynamics studies. Sensitivity studies investigate the impact of an inefficient deployment mechanism on the reflector surface, especially in 1D deployment, identifying allowable tolerances for hinges and springs.

The paper is organized into various sections, starting with an introduction and targeted use case in Section-I. Section-II delves into design, deployment, and space environment requirements, considering trade-offs and decision criteria. Section-III analyzes various design studies, encompassing RF design, deployment mechanism, and integration trade-offs, leading to a preliminary antenna design. Section IV concludes the paper, suggesting possible next steps for further developments.