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Author: Mr. Panagiotis Bountzioukas
Aristotle University of Thessaloniki, Greece, mpountzi@math.auth.gr

Mr. Georgios Kikas
Aristotle University of Thessaloniki, Greece, kikasgiorgos@gmail.com
Mr. Christoforos Tsiolakis
Aristotle University of Thessaloniki, Greece, c.tsiolakis@spacedot.gr
Mr. Dimitrios Stoupis
Aristotle Uiniversity of Thessaloniki, Greece, dstoupis@auth.gr
Ms. Eleftheria Chatziargyriou
Aristotle University of Thessaloniki, Luxembourg , elefthca@math.auth.gr
Ms. Vasiliki Kourampa-Gottfroh
Aristotle University of Thessaloniki, Greece, vkourampa@meng.auth.gr
Mr. Aggelos Mavropoulos
Aristotle University of Thessaloniki, Greece, mgangelos@meng.auth.gr
Mr. Ioannis-Nikolaos Komis
Aristotle University of Thessaloniki, Greece, komisioann@meng.auth.gr
Mrs. Ilektra Karakosta-Amarantidou
Università degli Studi di Padova, Italy, ilektra.karakostaamarantidou@unipd.it
Ms. Afroditi Kita
Aristotle University of Thessaloniki, Greece, afrodikita@ece.auth.gr
Prof. Alkiviadis Hatzopoulos
Aristotle University of Thessaloniki, Greece, alkis@ece.auth.gr
Mr. David Palma
European Space Agency (ESA/REDU), Belgium, david.palma@esa.int
Mr. Loris Franchi
European Space Agency (ESA), Belgium, Loris.Franchi@ext.esa.int

THE EVOLUTION FROM DESIGN TO VERIFICATION OF THE ANTENNA SYSTEM AND MECHANISMS IN THE ACUBESAT MISSION

Abstract

AcubeSAT is an open-source CubeSat mission aiming to explore the effects of microgravity and radiation on eukaryotic cells using a compact microfluidics platform. It is developed by SpaceDot, a volunteer, interdisciplinary student team. The main scientific return of the mission is quantified as images of the on-board experiment taken with a camera integrated in the setup, which have to be efficiently downlinked back to Earth despite their remarkable size given our data budget limitations. Considering the imminent need for telecommand and telemetry support, the efficient transmission and reception of data proved a challenge, which was escalated due to the scarcity of open space technologies and lack of space engineering expertise in Greek academia. Thus, the student team tackled various design iterations for AcubeSAT's antenna system, with methods this paper aims to elucidate.

At the early stages of development, a dual-band patch antenna was designed aiming to support both

uplink and downlink in two frequency bands to support telemetry, telecommands and mission images through one single antenna. However, this development path got abandoned quickly because of the extremely stringent pointing requirement placed upon the attitude control subsystem, which is the most prone to malfunction. Thus the decision was made to demultiplex the transmission flow into two separate antennas, one single band patch antenna for the payload pictures and one deployable turnstile antenna for telemetry and telecommand. The first, transmitting at 2.45 GHz, was designed and prototyped in-house, while for the latter, numerous efforts to integrate various open-source designs took place, however the system architecture and budgets were hindering the process. Eventually, a risk-assessment indicated that the Antenna Deployment Mechanism (ADM) should also be developed in-house, tailored to AcubeSAT's needs and requirements, while being open-source and cost-effective.

Consequently, given the approaching CDR close-out, rapid development and prototyping took place. This quickly led to the first manufactured Engineering Qualification Model of the project, the in-house ADM. Although ambient tests in the university cleanroom proved promising, environmental tests were the ones to signify this component's reliability and repeatability, for instance regarding characterization of the temperature range where deployment is reliable. In fact, an environmental campaign, including TVAC and vibration tests conducted in December 2022, achieved exactly that, while aiding the team identify the components' weaknesses, to be addressed in the final model. The flexible approach that enabled the team to reach a validated design, is described in this paper.