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COMMUNICATION ARCHITECTURE AND OPERATION STRATEGIES FOR THE ELECTRICALLY PROPELLED CUBESAT AND RE-ENTRY CAPSULE SYSTEM CAPE

Abstract

The range of applications supported by CubeSats has evolved. Multiple technologies converged due to improvements in micro-systems, communications and sensing. A breakthrough of propulsion technologies and nanoscale satellite applications is imminent, and all of them are enabling an increase of mission flexibility and novel ways of conducting science, while providing a cost-effective platform. CAPE, the CubeSat Atmospheric Probe for Education, is a 2U-CubeSat platform for testing a novel electric-propulsion system in low earth orbit, which carries the smallest deployable miniature re-entry capsule. The Service and De-orbit module is equipped with a pulsed plasma-thruster (PPT) for orbit and re-entry control, developed by the Institute of Space Systems of the University of Stuttgart (IRS). Due to the resulting demise this mission will not produce space debris.

This mission is a first of its kind as the re-entry capsule is an autonomous system with dedicated communication equipment active during re-entry and the service and de-orbit module with an own com-system that will transmit housekeeping and e-thruster performance characteristics. For achieving this a new communication architecture is required serving the needs of a standard CubeSat with respect to TMTC.

The mission design drivers are the PPT PETRUS and the capsule itself. The thruster will successively adjust CAPE's orbit. Permanent tracking is required to validate thruster effectivity and maintain the com-link. Furthermore the plasma will be an interference source to the communication system during re-entry. The communication architecture shall be robust against these effects. The capsule has its own communication system for transmitting scientific data while travelling through the atmosphere. The driving requirement is the data completeness of both systems.

The study provides selection criteria of the different frequency bands, the properties of the communication system onboard, the ground segment infrastructure and more. It is part of the feasibility study in the preparation phase of CAPE. The presented design approach shall serve as reference for CubeSat missions of similar scope.

CAPE was started in 2014 and is actively supported by KSat at the IRS. It took part in the DLR/ESA REXUS2016 sounding-rocket campaign and conducted a re-entry capsule experiment. The Distributed

Ground Station Network is a research topic at the Institute for Photogrammetry at the University of Stuttgart and took part Google and ESA Summer-of-Code campaigns in 2013-2017 and will be validated with an experiment onboard REXUS2018. The results of this study are presented in this paper. CAPE is designated for launch from the ISS.