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MISSION DESIGN AND ANALYSIS OF A POCKETQUBE SWARM MISSION FOR DISTRIBUTED BEAMFORMING

Abstract

A tendency towards miniaturisation of electronics, along with a reduction in launch costs, have enabled the growth of the miniaturised spacecraft missions. Satellites such as CubeSats have widened access to space, with several missions already operating in orbit and many more being planned. Still, even smaller sub-CubeSat-sized spacecraft such as PocketQubes and ChipSats could enable unprecedented missions that are not possible with traditional-sized satellites. One of the advantages of miniaturised platforms is the capability of flying in swarm configuration, allowing distributed scientific and technological operations. One of these applications is distributed beamforming where, instead of deploying a spacecraft with a single large antenna, a swarm of satellites is used as a distributed antenna array to obtain an electronically steerable beam. Adopting sub-CubeSat platforms for distributed beamforming presents the opportunity for applications in which the relative displacement between antenna elements needs to be larger than the one allowed by a monolithic satellite. However, several challenges are also encountered since their capabilities are limited with respect to larger satellites. This paper introduces for the first time the mission design and analysis of a distributed beamforming mission adopting PocketQube satellites. First, it details the low Earth orbit dynamics of a PocketQube swarm formed by a master node and a cloud of slave nodes, including the analysis of the orbital perturbations and the station-keeping strategy. An orbit control technique using solar radiation pressure and atmospheric drag is adopted to control the swarm geometry to achieve beamforming. Then, a system engineering study determines the spacecraft systems, sub-systems, and components to allow for beamforming in view of requirements and constraints of PocketQubes. Eventually, the swarm dynamics and the spacecraft engineering studies are coupled to the beamforming principles and characteristics to assess the performance of the PocketQube swarm to achieve beamforming.