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RYF3EX: RYERSON FEMTOSATELLITE FORMATION FLYING EXPERIMENT MISSIONS FOR EARTH OBSERVATION

Abstract

The Space Systems Dynamics and Control (SSDC) laboratory of Ryerson University has proposed Ryerson Femtosatellite Formation Flying Experiment (RyF3Ex) missions for Earth observation. RyF3ex-1 mission consists of multiple tethered femto-satellites while RyF3ex-2 mission involves a formation of multiple femto-satellites. Each of these satellites weighs less than a 100 gram with its size of a small mobile device (5 cm x 10 cm). They are equipped with a tiny camera (weighing less than 25 gram) as a payload. A 300 kilopixel CMOS optical camera is considered and it consumes a modest power supply of 10mW. Spatial resolution when imaging the Earth's surface is low however, due to the constraints on focal length the femtosatellite package imposes. Co-orbiting objects could be imaged with high spatial resolution depending on the formation.

The main objectives of the RyF3Ex missions are: (a) test command and control architecture and hardware, (b) formation keeping and reconfiguration control algorithms, (c) communications protocol and data relay, and (d) imaging of the Earth's surface. In the RyF3ex-1 mission, a new tether configuration is proposed for passive attitude stabilization of the satellites. In the RyF3ex-2 mission, tiny thrusters and magnetic torquers are considered for orbit and attitude control of satellites. The control laws are developed to provide required thrusts and torques for desired formation precision. The attitude determination and control system is designed to stabilize the satellite on all three axes and to provide proper pointing throughout the mission lifetime. The attitude determination system relies solely on the three axis magnetometer to make attitude measurements in conjunction with a Kalman filter. The attitude control system uses a combination of 3 magnetic torque actuators and passive drag stabilization to provide pointing of the antenna and payload to the nadir. The magnetic torquers each achieve a dipole moment of 0.01 amp-turn-square meter. The two in-plane torquers are ferrite cored, whereas the out of plane torquer is open core. Significant mass savings are realized by using AWG30 aluminum wire instead of the copper equivalent, especially with the open core z-axis torquer. The total mass of the attitude actuators is 12.85 grams. Results of the numerical simulations establish the feasibility of the proposed missions. The paper presents in detail about these two missions including their deployment in space.