ATTITUDE DETERMINATION, CONTROL AND OPERATING MODES FOR CONASAT CUBESATS

Valdemir Carrara[(1)], Hélio Koiti Kuga[(2)], Philipe M Bringhenti, and Manoel J M de Carvalho [(3)]

[(1)(2)(3)(4)] *Space Research National Institute-INPE, Av. dos Astronautas, 1758, São José dos Campos, SP, Brazil, 55-12-3208-6183, valdemir.carrara@inpe.br, helio.kuga@inpe.br, manoel@crn.inpe.br*

Keywords: *Cubesat, satellite attitude determination, satellite attitude control, satellite operating modes*

ABSTRACT

CONASAT is being designed (Phase B) to gather environmental data like rain volume, temperature, humidity, air pollution, ocean streams, environmental hazards, etc. collected and transmitted to satellite by remote platforms on ground, and to retransmit them to the mission center. At least two identical satellites shall be launched, and, together with their antecessors SCD1 and SCD2 (Data Collecting Satellites 1 and 2, from Brazil) launched in 1993 and 1998, respectively, and still operating, they will provide large temporal resolution for environmental monitoring. In order to keep the costs low, CONASAT shall be based on CubeSat technologies. However, the large power required by onboard data transponder implied an arrangement of 8 CubeSat units in a single cubic one, with 230 mm size. All internal subsystems shall be duplicated in cold redundancy, in order to assure the reliability. Also, in order to fulfill the power requirements, the attitude shall be Earth pointed, since the payload antenna will face to ground. Although there is no restraint in pointing requirements, a set of 3 off the shelf reaction wheels will be employed so as to assure satellite maneuverability and attitude stabilization. Attitude determination will rely in a set of 6 coarse sun sensors (one in each cube face) and a tri-axes magnetometer. QUEST algorithm together with Kalman filter will provide onboard attitude determination and estimation whereas attitude control will be based on a conventional PID, acting on the reaction wheels, and 3 magnetic coils necessary for wheel's dessaturation. Onboard software reliability is assured by minimizing the number of operating modes. Besides the nominal and stand-by modes (for Earth pointing and station keeping, respectively), the attitude acquisition mode and the safe mode for attitude de-tumbling shall be accomplish by means exclusively of the magnetometer (Bdot algorithm) and the torque coils. Since there is no complete attitude determination on the shadowed part of the orbit, the nominal mode is achieved only after Kalman filter convergence. It is expected that the filter covariance grow in the Earth's shadow, but remains in an acceptable level so as to keep the satellite attitude still stable. This strategy is less risky and therefore more reliable than switching between operating modes twice an orbit, from nominal to safe and back to nominal. It remains to be investigated the communication link during night pass, since the attitude deviation from the nadir pointing shall be larger than during daylight pass. This work will present the attitude control modes for CONASAT, as well as the transition conditions between modes. The results from the simulated attitude determination, estimation and control will be addressed, with focus on the attitude performance in the worst condition for both nominal and safe modes. The wheel's dessaturation

strategy consists of a magnetic control law that maximizes the torque in the opposite direction of the total satellite angular momentum. Due to its symmetry, is expected that the major perturbation source on the attitude shall be the residual magnetic moment, caused by unbalanced electric currents, and some onboard magnetic materials. This work shall constitute a base line that will guide the on-board control software development, integration, and qualification tests.