



www.DeepakPublishing.com

Rawashdeh, S., et al. (2013): JoSS, Vol. 2, No. 1, pp. 85-104
(Peer-reviewed Article available at www.jossonline.com)



www.JoSSonline.com

Aerodynamic Stability for CubeSats at ISS Orbit

Samir A. Rawashdeh and James E. Lumpp, Jr.

Space Systems Laboratory, Electrical and Computer Engineering, University of Kentucky, Lexington, KY

Abstract

At altitudes below 500 km, satellites experience a significant amount of aerodynamic drag that can be utilized to stabilize satellites to align with the relative wind direction. Designing a non-rotating spacecraft such that the center of pressure is behind the center of mass provides an aerodynamic restoring torque, which in combination with an oscillation damping system provides stability and alignment with the spacecraft velocity vector. Passive aerodynamic stability and damping has been demonstrated on orbit by the Soviet Union on Cosmos-149 and Cosmos-320 in 1967 and 1970, respectively, and by NASA on the Passive Aerodynamically Stabilized Magnetically-damped Satellite (PAMS) spacecraft, deployed from STS-77 in 1996. This paper presents our analysis of aerodynamic stability solutions for the CubeSat domain. CubeSat form factors are significantly smaller and lighter than the previous flight demonstrations; moreover, they must fit inside a CubeSat launcher, and only deploy aerodynamic elements post orbit-insertion. We describe completely passive solutions for 3U and 1U CubeSats, where aerodynamic fins are deployed and magnetic hysteresis material is used for oscillation damping. We also show that greater velocity vector alignment can be achieved using active rate damping, using a magnetometer and magnetic torque coils running the B-dot control law to provide improved oscillation damping. Component selections are offered to create off-the-shelf aerodynamically stable CubeSat platforms, and we conclude that passive aerodynamic stability is suitable for the altitude and inclination of upcoming CubeSat flight opportunities on International Space Station (ISS) crew re-supply missions.

1. Introduction

Passive attitude stabilization, in general, is an attractive attitude control solution for satellites when coarse pointing is required, especially if power, mass, and volume are constrained. Tuning and designing the

spacecraft to specific geometric, mass, and magnetic properties can provide passive attitude control, without the need for active sensors or actuators.

Magnetic, gravity gradient, and aerodynamic torques are the main sources of moments on Small Satellites in Low Earth Orbit (LEO). Solar radiation pres-

Corresponding Author: Samir Rawashdeh, samir.rawashdeh@gmail.com
Publication History: Submitted – 09/17/12; Published – 08/07/13

Copyright © A. Deepak Publishing. All rights reserved.

JoSS, Vol. 2, No. 1, p. 85