Paper ID: 73058
oral

29th IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Generic Technologies for Small/Micro Platforms (6A)

Author: Dr. Anja Nicolai
Astro- und Feinwerktechnik Adlershof GmbH, Germany, a.nicolai@astrofein.com

Mr. Thomas Terzibaschian
DLR, German Aerospace Center, Germany, thomas.terzibaschian@dlr.de
Dr. Christian Raschke
Astro- und Feinwerktechnik Adlershof GmbH, Germany, c.raschke@astrofein.com
Mr. Heiko Jahn
Astro- und Feinwerktechnik Adlershof GmbH, Germany, h.jahn@astrofein.com
Mr. Roy Bretfeld
Astro- und Feinwerktechnik Adlershof GmbH, Germany, r.bretfeld@astrofein.com

SOFTWARE AND HARDWARE IN THE LOOP TESTS - FROM PICO TO SMALL SATELLITES WITH AIR BEARING TEST STANDS

Abstract

Attitude control is the control of the orientation and angular rate of a satellite while the center of gravity follows the rules of orbital mechanics. A well-known and power-ful tool for developing, testing and verifying an attitude control system (ACS) on the ground is a test bed with an air bearing. It can almost perfectly simulate the low-torque situation of a satellite in space. The paper gives a brief introduction to the mathemati-cal and physical principles of such an air bearing test stand. The use of such an air bearing test stand is related to the test philosophy of a satellite project. It is the trade-off between purely analytical and software examination of atti-tude determination and attitude control algorithms or the use of hardware-in-the-loop simulation (HILS) and software-in-the-loop simulation (SILS) in conjunction with an air bearing test stand. Experience has shown that the tests on the air bearing test stands tend to reveal errors in the ACS algorithms, that are not necessarily found with pure software verification and helped to avoid such surprises later in space. The physical design of modern air bearing test stands is a combination of several com-ponents. There is the air bearing itself, the simulation of the satellite's moments of inertia and the matching of the center of gravity with the air bearing's center. The bearing itself and the deviations of the real center of gravity from the ideal position introduce a residual disturbance moment, but at a level comparable to typical disturb-ance moments for small satellites in LEO orbits. It is important to simulate the correct satellite moments of inertia with as little weight as possible of all the material mounted above the air bearing. Any connection of the device under test (DUT) to the environment must be wireless to keep the disturbance torques as low as possible. Therefore, the power supply must be part of the DUT. To minimize the total mass by approximating the correct moments of inertia, the best option is to place only the necessary components of the satellite on the test stand, ra-ther than mounting a "complete" satellite model there. The test bed can be extended to include geomagnetic field simulation for a given orbit and initial conditions, solar simulation, GPS simulation, and even star tracker simula-tion. An external reference system could also be included, that allows precise tracking of the movement of the DUT. A realistic test scenario is associated with a clear defini-tion of some coordinate systems, which must be correctly arranged in a laboratory fixed coordinate system. This includes setting the simulation time and will be ex-plained with examples of simulating earth pointing, sun pointing, and the trickier pointing to a fixed target on the ground. The independent tracking system allows accu-rate verification of platform rotations with arc-second accuracy. In the last decades, there has been a rapid

development of such test beds for different classes of satellites from -satellites (moments of inertia up to 20 kg*m) to nano-satellites and 1 U picosatellites. The paper is based on the experience and know-how of the private company Astro-Feinwerktechnik Adlershof GmbH and the experience in using different air bearing test beds for small satellite projects e.g. at the German Aer-ospace Center (BIRD, TET-1, BIROS) or in their own test laboratories.