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FROM USE IN EARLY 3-AXES-CONTROLLED SATELLITES TO CURRENT CUBESAT FORMATIONS: EVOLUTION IN USE OF PRECISION TURNTABLES

Abstract

The new approach of 3-axes stabilization was introduced end of the 70ies to Sun and Earth sensors to point the satellite's antennas towards Earth and the solar arrays for energy generation towards the Sun. The German Aerospace company Messerschmidt-Bölkow-Blohm GmbH (MBB) developed around 1980 for the telecommunication satellite INTELSAT V (launched 1982) a turntable Dynamic Bench Test Facility (DBTF) based on two three-axes motion simulators to appropriately simulate and test related flight dynamics of 3-axes attitude control systems. Subsequently further 32 telecommunication satellites with this innovative attitude control system were realized and tested, as well as Earth observation and scientific satellites including Rosat, Astrospas, Eutelsat II. Here hardware and software performance related to guidance, navigation, control and data handling tasks were characterized by Hardware-in-the-Loop (HiL) experiments. An Earth simulator for geosynchronous and low Earth orbit spacecraft, as well as Sun and Star simulators provided the appropriate test environment. Actuation in the 3 rotation axes was achieved by two hydraulic outer loops and an electric inner loop. Thus high dynamics with maximum accelerations up to 10 000 deg/s2, and a velocity range from 10-4 deg/s to 200 deg/s were realized at an accuracy of 10-4 deg.

When MBB (then part of Airbus Space) retired this facility, it was acquired by S4 – Smart Small Satellite Systems GmbH Würzburg. Since 2016, the initial analog technology was smoothly transferred to a new digital environment in order to achieve now even better performance than originally. Today the two precision turntables are used beyond the earlier attitude control and sensor calibration HiL-tests also for multi-satellite system tests. This includes optical inter-satellite links, sensor calibrations, joint observations by cameras from different perspectives, relative navigation performance and self-organization of satellite formations for optimum data acquisition. The Telematics earth Observation Mission (TOM), composed of 3 CubeSats, is prepared in final tests for a launch at end of 2023. It requires coordinated attitude control to generate by photogrammetric data processing 3D-images of ash clouds from volcano eruptions. Next in the queuing line for the turntables is CloudCT, a mission composed of 10 cooperating CubeSats, for characterizing the interior of clouds through computed tomography methods in order to improve climate predictions.

Thus the solid infrastructure of the historic turntables serves the purpose of advanced attitude control tests of single satellites for more than 40 years, but currently they open innovative application potential to test also modern multi-satellite systems appropriately.