Paper ID: 43656
student

IAF SPACE OPERATIONS SYMPOSIUM (B6)
Mission Operations, Validation, Simulation and Training (3)

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DANCE: A FRICTIONLESS 5 DOF FACILITY FOR GNC PROXIMITY MANEUVERING EXPERIMENTAL TESTING AND VALIDATION

Abstract

In the last decade, the space community showed increasing interest in fractionated space segments flying in formation, as one of the key enabling strategies to step further in missions' quality and performances. Formation Flying introduces new possibilities for the space engineering, but it obviously also poses new challenges due to the low level of technology maturity. Here comes the need for testbeds, to strengthen the innovative technological solutions – hardware and software - prior to fly. The paper presents DANCE (Device for Autonomous guidance Navigation Control Experiments), the Politecnico di Milano Aerospace Science and Technology Department facility to serve as testbed for experimental verification of formation flying hardware and software. The facility is composed by a frictionless table and two vehicles: DANCERS (Device for Autonomous guidance Navigation Control Experiments on Relatively moving Spacecrafts) - with a total mass of about 40kg, 5kg of which available for the testing units - move freely on air bearings on the 3x3 m glass table. Each DANCER ensures 5DOF, 2 translational and 3 rotational, obtained by means of 3 planar and 1 hemispherical air bearings. DANCERS include:

- Lower Platform (LP) supporting three air bearings, to ensure the DANCERS frictionless planar motion. Two carbon-fiber vessels are located on the LP too, which feed all air bearings on board and ensure a 30 minutes experimental campaign. LP contains also the pedestal which supports the hemispherical air bearing.
- Attitude Platform (AP) mounted on the hemispherical bearing which provides full rotations in yaw and $\pm 45°$ in pitch and roll; AP accommodates the set of 12 cold gas thrusters for translational and rotational control and three Reaction Wheels for fine attitude control. AP is also equipped with a complex balancing system to remove any possible misalignment between center of rotation and center of mass.
- The Upper Platform (UP) hosts all electronics and navigation sensors: the main on-board computer (OBC), the batteries, the communication modules and power transformers; an Inertial Measurement Unit (IMU), an optical camera and markers for the IR external tracking system compose the sensors set. The UP offers the volume for the possible hardware to test, therefore a payload slot to supply the payload with power, I/O ports and communication is here located.

The paper discusses DANCE design and presents the ground facility performance and interfaces offered for GNC and FF testing, critically discussing the characterisation and calibration campaign results.