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# DANCE: INTEGRATION AND AVIONICS TESTING OF 5 DOF EXPERIMENTAL FACILITY FOR RELATIVE GNC

**Abstract**

DANCE is an on-going research project at Aerospace Science and Technology Department of Politecnico di Milano aimed at developing a 5 DOF multi-vehicle frictionless facility for on-ground testing and validation of spacecraft GNC maneuvering. DANCE borrows from existing spacecraft simulators the architecture employing a set of three linear and one hemispherical air bearing to simulate the force-less and torque-less environment. However, differently from existing spacecraft simulators, DANCE is meant specifically to test control algorithms for missions involving swarm of satellites along with other innovative software such as robotic arms deployment and net-capturing. DANCE facility will consist of two DANCERS moving on a 9 $m^s$ glass table 10 $mm$ thick, supported by a structure made of self-leveling epoxy resin for maximum rigidity, and an absolute navigation system, composed of four infrared cameras that track dedicated markers mounted on each vehicle. The tracking system is meant to estimate the absolute position and attitude of each DANCER with an accuracy, respectively, of $\sim 3$ $mm$ and $\sim 0.4^o$. The development of the first DANCER vehicle comprises several subsystems, essential for the preliminary test of the whole facility. In particular, the paper presents the full design and testing campaign performed on the complete propulsion system, the calibration and development of the avionics hardware and software as well as the manufacturing, analysis and testing of 3D-printed emispherical air-bearing. The propulsion system is composed of high-pressure air vessels, which feed four thrusters assemblies. Each thruster assembly is composed of three high-speed servo-valves and an accelerating nozzle to generate thrust. An extensive testing campaign has been performed to characterize the dynamic response of the subsystem. Collected data have been analyzed using the tools of statistical analysis. The experimental setup for each test is presented in the paper and the results confirmed the suitability of the system according to performance requirements. Moreover, the paper presents the design and integration of the on-board avionics, both in terms of software and hardware. The procedure for the development and deployment of control and navigation algorithms is described, with the particular focus on the compatibility and the aim of fast prototyping. Successful functional tests have been performed with the navigation and control algorithms for the main actuators, namely the aforementioned servo-valves and the electric motors driving the reaction wheels. A rigorous calibration routine has been defined in order to assess actual performance of the sensor suite, comprising IMU and magnetometers.