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MISSION OVERVIEW OF THE DYNAMIC MANIPULATOR FLIGHT EXPERIMENT (DYMAFLEX): A NANOSATELLITE TEST BED TO STUDY COUPLED DYNAMICS BETWEEN A ROBOTIC ARM AND AN EQUIVALENTLY-SIZED SMALL HOST VEHICLE IN THE SPACE ENVIRONMENT

Abstract

Robotic arms have been proven to be extremely useful in the space environment. These manipulators have been fairly slow, with a tip mass velocity on the order of a few cm/s, and attached to large host vehicles to counter-balance the dynamics. These large host vehicles and manipulators are expensive both in terms of development time and money. One of the design benefits of a slow moving arm on a large host vehicle is that the coupled dynamics are not an issue. Moving the arm at low speeds when attached to large host vehicle will result in small (i.e negligible) motions in the base vehicle. The dynamic manipulator flight experiment (DYMAFLEX) refers to the design of two new components: a high performance 4DOF manipulator, capable of a tip speed in excess of 25 cm/s, and a small host vehicle capable of active stabilization using reaction wheels and cold gas thrusters. The relative mass between the spacecraft and manipulator is 5.3, whereas previous systems incorporating a robotic arm such as Orbital Express and ETA-VII have relative masses of 15 and 24, respectively. The effects of the coupled dynamics caused by DYMAFLEX's low relative mass are anticipated to be significant. The manipulator will perform a variety of trajectories and the dynamics will be recorded and transmitted by IMUs located throughout the spacecraft and a single IMU which will be located on the end-effector. Initial experiments will be done without any active stabilization, allowing the simulations to be verified. Reaction wheels will then be used to actively stabilize the spacecraft while the manipulator performs trajectories. Finally, cold gas thrusters will be used in addition to reaction wheels to actively stabilize the spacecraft. Cold gas thrusters are used in addition to the reaction wheels to counter large moments caused by faster movements The coupled dynamics between manipulator and spacecraft can be significant depending on tip speeds and the relative mass between the spacecraft and the manipulator. Being able to accommodate the coupled dynamics between a manipulator and similar-sized host vehicle will allow smaller, and thus cheaper, vehicles to be able to use high performance manipulators to perform tasks such as satellite servicing faster. This report will summarize the entire mission, subsystems, and initial results of the DYMAFLEX project.