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Author: Prof. Inna Sharf
McGill University, Canada

Mr. Benjamin Thomsen
McGill University, Canada

EXPERIMENTS ON TETHER-NET CAPTURE AND NET CLOSING MECHANISM OF SPACE DEBRIS

Abstract

The use of tether-nets to capture space debris is considered one of the more promising strategies for the Active Debris Removal (ADR) mission, specifically of large debris. The concept involves ejecting a net with corner masses from the chaser spacecraft towards the debris, with subsequent net deployment, envelopment and securing of the net around the debris. The nominal advantages of this strategy for ADR are robustness to debris size and shape, as well as its tumbling motion and misalignment errors in the deployment; indeed, these advantages have been ascertained through a number of sensitivity studies conducted to date.

Several groups, including researchers at McGill, have been working on issues related to modeling of both the net deployment phase and debris capture phase and a number of simulation results have been reported in literature. Experimental validation of the developed models is a difficult undertaking, however, since one needs to reproduce the gravity-free conditions of space in a terrestrial environment. Most notable experiments on net deployment and mock-up debris capture have been conducted in the past year on aircraft during the near zero-gravity parabolic flights.

Two objectives are set out for the present manuscript. First, we present the design of a laboratory-based test-bed prototype for testing aspects of the capture phase of a mock-up debris with a deployed, i.e., fully open, tethered net. Being a ground-based facility, the test-bed is operated in the Earth's gravitational field which in fact, after release of the net, ensures the envelopment of the mock-up debris. Nevertheless, we contend that the test-bed can serve as a useful tool for studying and validation of a number of aspects of the tethered-net debris capture. Our second objective is to present the design of a net closing mechanism for securing the net around the tumbling debris. We propose a simple net closing concept, referred to as tether-actuated net closure mechanism. In this approach, the actuation of the net closure is accomplished through the towing tether, which functions as a cinch cord by extending along the perimeter of the net, so that pulling on the tether will reduce the perimeter of the net mouth, thereby securing the debris within the net. Experiments demonstrating both the operation of the test-bed and the closing mechanism will be reported in the paper.