SPACE DEBRIS SYMPOSIUM (A6)
Poster Session (P)

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A TOOL TO EFFECTIVELY DESIGN TETHERED NET DEVICES FOR SUCCESSFUL ACTIVE DEBRIS REMOVAL

Abstract

The space debris removal and generation containment in Earth orbits is a well-known and urgent issue to be faced to mainly preserve the safety of the current and future active space systems. From a removal system design point of view, the more the general purpose it is the more cost effective would be. On the other side, the more general purpose it is, the less effective it may turn to be. In fact, a general purpose removal system design should effectively intervene on objects completely different in configuration, materials and possibly in dimensions such as fragments, entire/parts-of dismissed satellites and third stages/fairing elements. Moreover, elements to be managed do not cooperate and have a complex, free, not completely known dynamics. Different techniques are being proposed in literature, starting from the classical robotic arm, dedicated to a narrow and specific class of debris which present parts the robotic arm can grasp to, up to action-reaction principle exploitation with no contact at all, such as gas plume impinging on the non-cooperative element to change its momentum. The paper updates the work currently on going at Politecnico di Milano to design, characterize and test an in between solution: a net, shut from an active satellite, that embraces the debris element, close around it and thanks to an active box, tethered connected with the net, drag it to the disposal position in space. The problem has been deeply analyzed to simulate at the best the net deployment, contact and closure dynamics on the target. Starting from their previous works results, the authors here add the critical discussion about the effectiveness of a planar net versus a 3D (either conical and pyramidal shape) net configuration solution according to the size, mass and configuration of the class of targets to be wrapped. Sensitivity of the removal control law with respect to the target-chaser mass ratio has been studied and it's here presented. The already implemented numerical simulator, focused on driving the real device sizing and integration, has been upgraded by taking into account damping features of the threads materials and torsional effects imposed by the free motion of the target on the chaser through the connecting tether, to better match the available experimental results. The Technology roadmap and a preliminary cost budget to finalize a In Orbit Demonstration mission is also discussed.