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AN ALTERNATIVE SPACE DEBRIS REMEDIATION OPTION: BRINGING MASSIVE DERELICTS BACK TO LIFE USING NANO-TUGS

Abstract

The growth of the future debris population will be largely driven by collisions between massive derelict objects (i.e., abandoned rocket bodies and defunct payloads). The traditional approach to reducing the possibility of such an event is active debris removal (ADR) whereby a large object is grappled, detumbled, and moved into a re-entry trajectory. Due to the enormity of these objects (i.e., 1,000 to 9,000 kg) the ADR operations will be taxing and the re-entry hazard will be significant. As a matter of fact, it is likely that all of the objects with mass greater than 1,000 kg will require controlled re-entry which will add even more stringent requirements to the ADR solution. ADR remediates the collision risk of massive derelicts by removing them from orbit, however, another remediation option is to rather prevent the derelicts from colliding without removing them from orbit.

While there are a variety of remediation options to ADR that prevent massive objects from colliding such as Just-in-time Collision Avoidance (JCA) and Large Debris Traffic Management (LDTM), this paper examines a different alternative called a nano-tug. It is proposed that one or more small (i.e., 3U to 6U cubesat) nano-tugs be deployed as a cooperative swarm to attach to massive derelicts. A nano-tug has, at a minimum, (1) a simple grappling mechanism, (2) an electric propulsion system, (3) embedded accelerometers, and (4) a Global Positioning System (GPS) transceiver. This combination would enable the detumbling and stabilization of the derelict; create a position determination function for the derelict; and provide a rudimentary collision avoidance capability. The derelict objects will have been transformed from debris into a part of the space traffic whose safety will be managed through the expanding Space Traffic Management (STM) constructs.

Engineering designs that support the requirements of a nano-tug are reviewed and potential technological solutions are discussed. Key engineering parameters are identified and characterized: attachment mechanism, command control systems; maximum possible encounter velocity, power source, number of nano-tugs needed, scale of electric thruster systems, etc.