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SPACE DEBRIS SYMPOSIUM (A6)
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ACTIVE DEBRIS REMOVAL: CONSEQUENCES OF MISSION FAILURE

Abstract

There is widespread belief that Active Debris Removal (ADR) is needed to reduce the hazard posed by an increasing space debris population in low Earth orbit (LEO). Evolutionary models have demonstrated that the sustained removal of a few large debris objects can have a beneficial effect on the LEO debris environment. Following these studies, there has been a drive towards the development of technologies and concepts for ADR, with several on-orbit demonstration missions now proposed. However, the ubiquitous assumption made in modelling studies and the subsequent concept development has been that ADR always results in a successful mission outcome, i.e. the ultimate removal from orbit of the targeted debris and the chaser vehicle used. This is unrealistic, given that traditional space missions can, and do, fail on-orbit. Of real concern, therefore, is the potential for ADR to add to the space debris hazard. Three mechanisms exist through which the benefits of ADR may be lost: key debris targets may not be retrieved, new debris may be added in the form of failed chaser vehicles, or collisions involving the former objects may occur. The last mechanism is of particular concern because debris targets and failed chaser vehicles will be in highly populated regions of LEO. As such, the University of Southampton's DAMAGE model was used to evaluate the consequences of ADR failures for the intended remediation effort. A variety of chaser vehicle failures were simulated using DAMAGE in a 200-year projection of the LEO debris population $>$ 10 cm. Results showed that, for moderate chaser vehicle failure rates of 20% or worse, the effect of these failures was a growth of the LEO debris population, even when such a growth had been prevented by corresponding, but assumed 100% successful, ADR. Within the projections, a significant effort was focused on removing debris objects that were targeted by earlier, failed ADR chasers or even the failed chaser vehicles themselves, and up to one collision in ten involved an ADR target, chaser vehicle or fragment. Future efforts in ADR must move beyond the assumption of immunity to failure: consideration needs to be given to ADR technologies and concepts that are robust to failure and result in a benign impact on the environment in case of failure. Without such a move, there is a possibility that a remediation method, widely perceived as the only solution to the growing space debris hazard, could exacerbate the problem.