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Author: Mrs. Claire FREMEAUX
Centre National d'Etudes Spatiales (CNES), France, claire.fremeaux@cnes.fr

ASSISTED NATURAL RE-ENTRY: FROM CONCEPT TO TECHNICAL CHALLENGES

Abstract

Space debris presents a significant threat to space activity. In-orbit collision may cause damage to a spacecraft, leading to mission loss or degradation. As the number of uncontrolled satellites increases, so does the risk of a catastrophic collision between two large objects, which would generate thousands of additional debris. To avoid such a catastrophic event, two measures are of utmost importance. First, satellites must avoid collision during operational lifetimes. Second, satellites must leave their operational environment after mission completion. In low-Earth orbit, this means deorbitation, a set of manoeuvers decreasing altitude that will, later, cause atmospheric re-entry with partial disintegration. However, heavy elements may survive and these fragments can cause fatalities in inhabited area. Several international and national regulations establish that this risk must be assessed and limited to 10-4 per satellite. Usually, two types of deorbitation are carried-out. A controlled re-entry (CR) consists in a targeted set of manoeuvers placing the spacecraft on an immediate re-entry trajectory: scheduled to direct the ground impact to an uninhabited area (e.g. South Pacific Ocean Uninhabited Area or SPOUA), it minimizes the risk of human casualty and is perfectly suited to discarded orbital stages and large payloads. An uncontrolled re-entry (UR) consists in lowering the altitude only to the point where the residual orbital lifetime is lower than 25 years: the re-entry point and date cannot be predicted. The casualty risk is then spread out over all accessible latitudes, making it applicable only to small satellites. This paper examines a third way, introduced as semi-controlled re-entry or assisted natural re-entry (ANR). ANR consists in manoeuvring a satellite down to a very low orbit over several weeks or months, allowing the final natural re-entry to occur with one or two days, compared to an hour (CR) or years/decades (UR). The possible surface impact area can then be constrained to sparsely populated regions. This innovative concept brings significant benefits. It does not require high thrust deorbitation propulsion and saves on the fuel needed compared to a CR. It also is quicker than an UR, limiting the time in orbit. However, the technical challenges are numerous: manoeuvrability and control at very low altitude (¡200km), guidance and control of the descent, estimation of the final ballistic coefficient, operational aspects, ground system impacts, as well as ethical questions. This paper builds on previous analyses of ANR and identifies these challenges, presenting developed tools and identified solutions.