Space debris mitigation in geosynchronous orbit

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Since the dawn of the space age, geosynchronous orbits have been considered an essential resource for satellite applications. Today, a large fraction of the spacecraft put into orbit is bound to geostationary missions. Following the rapid increase in the number of spacecraft and apogee kick stages abandoned in such important region of space, a growing concern developed in the technical community regarding the possible overcrowding of this unique orbital regime. Later on, it became clear that spacecraft and upper stage break-ups, too, contribute to the geosynchronous debris environment. In order to preserve the synchronous region, the Inter-Agency Space Debris Coordination Committee (IADC) proposed and endorsed a re-orbiting strategy for spacecraft at the end-of-life: they should be disposed above the synchronous altitude and passivated, to reduce the risk of inadvertent explosions. The recommended perigee altitude of the disposal orbit took into account all relevant perturbations and was a function of the expected perturbing acceleration induced by solar radiation pressure. It was intended to prevent any further interference with a properly defined geostationary protected region.

This paper addresses several aspects related to space debris mitigation in geosynchronous orbit, reviewing the rationale and expected effectiveness of spacecraft end-of-life disposal. The analysis presented focuses its attention on: the role played by the initial eccentricity vector on the trajectory evolution of disposed satellites; the collision risk posed by debris clouds and the importance of passivation to prevent energetic break-ups; the impact of the operational limitations characteristic of aging spacecraft (e.g. reliability of residual propellant estimates, maneuver constraints and subsystems performance) on the definition of practicable disposal strategies; the potential problem represented by low energy, non-explosive, fragmentations leading to the release of debris with high area-to-mass ratio. Based on the modeling results obtained, some possible mitigation solutions are discussed, including possible enhancements or revisions of the IADC recommendation.