# Intact Derelict Deposition Study

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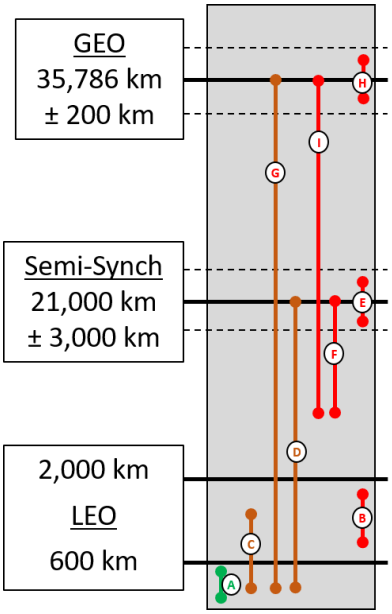
Abstract

The examination of clusters of derelict objects (abandoned rocket bodies [RB] and nonoperational payloads [PL]) in low Earth orbit (LEO) has highlighted their unique debris-generating risk. The "pure" clusters are four Russian-created concentrations of "paired" massive objects centered at 775 km, 850 km, 975 km, and 1500 km. The risk from these are significant as both the consequences and probability are larger than the "typical" collision event. The purpose of this study is to examine context of these clusters relative to all rocket bodies and nonoperational payloads (i.e., massive derelicts) that have been deposited over the space age. Observations are made to highlight the relative importance of debris remediation, debris mitigation, and collision avoidance.

This study was performed in February/March 2019 whereby all PLs/RBs still on orbit were logged by when deposited in orbit, current orbit, and country of origin. The diagram to the right portrays the orbital classes considered. "Long-lived" orbits include fairly circular orbit with perigee above 600 km (B/E/H) and elliptical orbits with perigee above 2,000 km (F/I). Orbits with uncertain lifetime are G and D (elliptical orbits with perigee below 600 km). Short-lived orbits are A and C (perigee below 600 km and apogee below 2,000 km).




The study focuses on three "circular" groupings: LEO (B: 600-2,000 km), semi-synch (E: 21k ± 3k km), and GEO (H: 35,786 ± 200 km).

It is observed that 36% of all rocket bodies ever used are still in Earth orbit; it is not getting better as 57% of the RBs deposited over the last 10 years are also still in orbit. For the three key circular orbit regions, the Russians are the overwhelming contributors:

- LEO (600-2000 km): 69% (~480 out of ~700);
- Semi-synch (21k ± 3k km): 70% (~63 out of ~90); and
- GEO (35,786 ± 200 km): 83% (~100 out of ~120).

However, China has "contributed" 41% of total RBs over the last five years in these three vital orbits: China left 8 RBs in semi-synch in 2018; 9% total over the space age.

The observations associated with non-operational PLs are much different than for RBs: there is growing use of (1) very low LEO orbits (below 600 km) for smallsats; (2) semi-synchronous orbit for several national position, navigation, & timing constellations; and (3) GEO by a diverse, global community with large spacecraft. The ambiguity of whether a payload is operational or not, complicates the analysis further.

In summary, this analysis tests the hypothesis that, despite the large number of massive objects deposited in a wide variety of orbits, the clustering of largely paired (i.e., both PLs and associated RBs) in long-lived LEO pose the greatest risk for large debris generating collisions over the next decade.