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Author: Prof. David Spencer
The Aerospace Corporation, United States

Mr. Daniel Pachura
The Aerospace Corporation, United States
Ms. Kerstyn Auman
The Aerospace Corporation, United States

LIVING IN CROWDS: SPACE TRAFFIC CONGESTION DUE TO LARGE LEO CONSTELLATIONS

Abstract

Several commercial companies, as well as other nations, have proposed deploying many satellites in Low Earth Orbit (LEO). These large constellations will greatly increase the number of satellites operating in relatively narrow regions of space. The added space traffic in these regions will create many close approaches between the member of the large constellations and other space operators. With close approaches, decisions need to be made as to whether to maneuver a spacecraft or not. Maneuvering a spacecraft not only uses consumable propellants, but many times, requires the maneuvering satellite to pause its mission during execution. The spacecraft may then resume its mission once the maneuver is over and the spacecraft is returned to its normal operations.

Maneuvering every time a close approach is predicted is not a feasible option. Depending on whether the objects involved in a close approach are active satellites (generally with lower positional uncertainties), or an active satellite and a debris object (one with a lower uncertainty and the other with greater positional uncertainty) different strategies can be taken. In heavily congested areas, there may be multiple times per orbit that two spacecraft come within some threshold metric. Most of these cases, a collision avoidance (COLA) maneuver would not be performed. There are, however, high-risk/high-certainty close approach cases when it is necessary to maneuver a spacecraft to avoid not just a close approach but a collision. Ultimately, any collision avoidance maneuver requires some expenditure of propellant, so estimating the frequency and the amount of propellant that would be used should be included in the maneuver budget that is developed during the design phase of the spacecraft.

This paper presents several estimation methods to help size collision avoidance maneuver budgets. Due to the lack of knowledge of specific locations of future satellites, statistical estimates can be made such that exact positions are averaged out and numbers of close approaches can be estimated, unless there are specific constellations where one variable is not distributed. Additionally, based on historical collision avoidance maneuvers for an existing satellite, a proxy of object flux known as COLA Rate Scaling can be used to estimate the relative increase in number of COLA maneuvers that would need to be made due to an increase in the satellite population. Lastly, this paper includes a discussion and shows examples of various collision avoidance strategies that could be implemented to increase the close approach distance.