20th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Interactive Presentations - 20th IAA SYMPOSIUM ON SPACE DEBRIS (IP)

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SIMULATION-BASED ANALYSIS OF FUTURE CONJUNCTIONS FOR THE DEVELOPMENT OF SPACE TRAFFIC MANAGEMENT SYSTEMS AND REGULATIONS

Abstract

Due to new business applications and lower launch costs the number of active satellites in Low Earth Orbit (LEO) has increased drastically in the last years and will further increase in the near future. This had led to an increased number of conjunctions between maneuverable spacecraft, which poses significant challenges for operators. The ability of both objects to perform active collision avoidance maneuvers may increase the risk of collisions in the case of insufficient communication, misinterpretation or an uncoordinated avoidance maneuver by both operators. To mitigate this risk specific "rules of the road" and means of communication and coordination between the operators are necessary.

To enable the formulation of such regulating principles and to define requirements for the necessary technical systems, the number and distribution of future conjunctions is analyzed in this paper. Therefore, today's satellite population as well as several planned satellite constellations are simulated over the timespan of multiple years, taking into account typical satellite and constellation operations (deployment, de-orbit, station-keeping), as well as the major perturbating forces. Different scenarios are generated by altering the number and the design (number of satellites, orbit parameters, duration of deployment operations, etc.) of the simulated constellations. The impact of these individual parameters on the number and distribution of the occurring conjunctions is statistically evaluated. The involved operators are analyzed and recommendations for the design and spatial distribution of future constellations are made to minimize the number of conjunctions. Potential rules that can be applied to resolve the occurring conjunctions are applied to these and the outcome (e.g., affected operators, mission types) is statistically evaluated.