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TETHERED TUGGING DYNAMICS ANALYSIS AND GROUND VALIDATION METHOD FOR SPATIAL ROTATING TARGET

Abstract

With the continual human spaceflight activities, the quantity of on-orbit spacecraft has increased dramatically. Till March 2017, 17995 large on-orbit operational targets have been monitored, including 4,420 payloads and 13,575 rocket bodies. The total number of fragments with the diameter of larger than 1cm is estimated to be in the millions order of magnitude, mainly distributed in low Earth orbit and sun-synchronous orbit at the altitudes below 2,000 km. In order to reduce the possibility of collision between each other, these spacecraft have to deorbit actively after the end of the lifetime. However, for fault spacecraft or various debris generating from lunch, there are no effective methods to mitigate the collision so far. Using active spacecraft to approach failure spacecraft or space debris, catching targets by tether net and tugging deorbit is the research hotspot of space debris mitigation methods at present. Since the tethered system is a fully flexible system, the dynamic model is complex. Especially when the spacecraft fails, it will eventually evolve into a spin-motion state with nutation under the free drift state. Then the dynamics will be more complicated. The simulation accuracy of tethered system motion state is directly related to the correctness of the design of deorbit tugging control law. In this paper, the satellites with nutation and spin motion after the failure have been selected as the tugging deorbit research object. Through simplification and rational design of tethered system, a simplified dynamic model has been designed, considering tethered-net knot position uncertainty, different rotating angular velocity and nutation angle. The dynamics and kinematics changes under various conditions have been analyzed meanwhile. In order to further verify the accuracy of the simplified dynamic model, a ground validation method is designed to simulate the change of the moving state of the target during the tugging process by using the kinematics simulation equipment. Besides the force on the target during tugging is obtained by the measuring device, which is fed back to the simplified dynamic model. The motion of the simulation equipment is driven by the simulation result of the dynamic model. Through a series of closed loop feedback, the correctness of the simplified tethered tugging model is verified.