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SPACE DEBRIS REMOVAL USING DRAG FORCE INTENSIFIER APPLYING CHARGED MEMBRANE: SYSTEM DESIGN AND FEASIBILITY STUDIES

Abstract

Expansion of space utilization activities increases the number of space debris, for example, a large-scale debris like the upper stage of a launch vehicle in congested orbit at altitude of 800-1000 km. These debris collide with others producing a lot of smaller debris that would cause further collisions to spacecrafts and destruction of the spacecraft in orbit. For these reasons, some low-cost debris removal systems are proposed, and a part of fundamental technologies had already been demonstrated in space by space agencies. One of a conventional deorbiting system uses a deployable membrane had already been demonstrated in orbit at the altitude of 400 to 600 km for a nano satellite, which encounters the orbital neutral particles to produce aerodynamic drag force. The drag force decreases orbital velocity of the spacecraft with the membrane resulting in deorbiting to the lower orbit to the earth. This type of system is very simple, but a large-scale structure is necessary to produce appropriate drag force to deorbiting a large-scale debris. In this research, we focus on the ions existing in the atmosphere at high altitude to enhance the drag force for the deorbiting system. The concept of the system utilize an ion sheath generated by a charged deployable membrane whose scale is considered to be up to 3 m3 m. In this paper, we introduce the system design of the debris removal system using the charged membrane. Also, feasibility studies for the system in low earth orbit (LEO) are presented; the performance of the system is studied by 1-D theoretical analysis as the variations of the atmospheric environment in LEO, and the potential structure around the charged membrane is analyzed by a 3-D electrostatic particle simulations to determine a proper method to bias the membrane. Also, laboratory experiments to detect the drag force on a scale model of the membrane in a flowing plasma is introduced to confirm magnification of the drag force onto the membrane with or without applied voltage to the membrane.