SPACE SYSTEMS SYMPOSIUM (D1)
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OPERATION OF A DUAL-MODE DISASTER MONITORING CONSTELLATION SUPPORTED BY AN ON-ORBIT SUPPLY DEPOT

Abstract

This paper proposes an operation rule for a mode change of a dual-mode satellite constellation and a methodology of designing and optimizing orbit elements of an on-orbit supply depot that supports the constellation. One of important characteristics of the proposed constellation is that it operates in two different modes – a nominal mode and disaster mode. The objective of the nominal mode is global weather monitoring in low Earth orbit (LEO). When a disaster breaks out, i.e. in the disaster mode, the constellation is reconfigured; some satellites are assigned to disaster monitoring missions and transfer to very low Earth Orbit (VLEO) to provide a better view in the vicinity of disasters. After disastrous situations are relieved, the satellites in VLEO return to their original orbits to resume the nominal mode. The extra amount of propellant consumed from this high-mobility maneuver is provided by the orbiting supply depot.

In order to fully utilize the dual-mode constellation, the operation rule for an orbit transfer, i.e. mode change, is necessary to address the following issues: 1) uncertain aspects of disasters, 2) sufficient work efficiency of left-over satellites performing nominal missions in LEO even during the disaster mode, and 3) fast response to disaster locations. The operation rule is designed considering these issues, while minimizing fuel consumption and maximizing access time and area both during the nominal and disaster modes. The rule helps decision makers to determine the number of satellites that should be assigned to the disaster mode, the orbital planes that the satellites should be transferred to, and the type of orbital transfer maneuvers, while considering the fuel consumption, operation efficiency of left-over satellites, and disaster uncertainties.

An optimal orbit selection for the on-orbit supply depot that can support the constellation to minimize the propellant consumption has been discussed. Trade-off study between the life cycle cost and the effectiveness of the system is carried out to derive the optimal number of depots for a given constellation configuration.

To sum up, this paper proposed an operation rule for mode change of the dual-mode constellation and the methodology for designing its supporting system, the on-orbit supply depot. By using the operation rule and design methodology for the on-orbit supply depot, the satellite constellation could be effectively designed and evaluated.