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SERVICE OPERATIONS OF SPACECRAFTS AS A SOLUTION FOR SPACE DEBRIS PROBLEM

Abstract

The modern cosmonautics faces a relevant problem of space debris mitigation in the near-Earth space. Space debris appears for two reasons. On one side, space debris results from lost pieces of spacecrafts, last stages of launch vehicles and upper stages. On the other hand, debris is formed from healthy space vehicles which exhausted all its fuel or from partially healthy spacecrafts with failed onboard equipment. The problem of servicing of such spacecrafts calls at present the attention of designers. In the report, we propose an integrated approach to solving the servicing problem of inactive space vehicle with its possible disposal if required. Both problems can be solved by a special automatic servicing spacecraft (SASS). The servicing problem, as well as the debris disposal problem, consists of three stages. The first phase is to search and dock with a selected spacecraft (SSC). This phase is preceded by the rendez-vous process with offset of errors due to lengthy injection. Prior to mating, a SSC is gripped using a robotic manipulator. This problem is aggravated by the fact that the SSC may be uncontrolled and rotate chaotically. Using its own software, the SASS determines the angular velocity vector and the attitude quaternion, and then develops a method to offset the perturbations on SASS after SSC gripping. This is followed by the gripping itself and the docking (after SC stabilization). The second phase is concerned with diagnostic testing. On this phase, a decision is made about the type of required activities: either disposal or fueling with fuel or gases in case the SSC onboard equipment is healthy. Single blocks can be replaced on the third phase if the SC onboard equipment failure root causes are identified. With this aim, the authors propose a block-modular SSC configuration, which will enable one to replace its blocks in flight. If the test results show that SSC servicing or fueling is inexpedient, then SASS performs a de-orbiting maneuver to place the SSC into a disposal orbit. As an example, we consider a servicing system for a GLONASS SC. The operational orbit of a SASS is 200 km lower than that of GLONASS. The system involves a launch vehicle and four SASS. A phasing maneuver is carried out to ensure a transfer to the rendez-vous point with a failed GLONASS SC. The design parameters of a SASS are determined.