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MULTIDISCIPLINARY OPTIMISATION OF FUTURE REUSABLE SPACE VEHICLE

Abstract

Mankind's presence in the Low Earth Orbit requires frequent low-cost transfer of cargo and crew. In order to improve the feasibility of space transportation from Earth to LEO, it's necessary to consider economically viable options including re-usable space vehicle with autonomous capabilities and improved re-entry. This paper represents the design of an aerodynamically modified spacecraft to meet human spaceflight and cargo mission requirements. The proposed orbiter design is a compact propulsive stage equipped with retractable wings and base flaps at the rear of the spacecraft. The wings along with flaps shall aid gliding re-entry which are initially housed inside during the launch phase, so as to meet the international launch vehicle guidelines and deployed after orbit insertion. The wings and the flaps will be actuated using shape memory alloys electromagnetic actuators. The base flaps ensure manoeuvre during the atmospheric re-entry phase, and activated when the efficiency of the control surfaces increase with the increase in dynamic pressure. The gliding re-entry with reduced g-load will thereby improve the effectiveness of re-entry strategies by reducing complexity and risks; parachutes may be considered as well for landing on any runway. The orbiter's Attitude and Orbital Control System ensures optimised trajectory with required ΔV from the initial injection orbit to the space station rendezvous orbit. The orbiter is capable of automatic docking at the orbiting laboratory being equipped with highly compatible space docking ring which ensures docking with multiple ports of the station. Multidisciplinary optimization is performed to meet mission objectives, considering the selection of aerodynamic shape required for wings, base flaps and the orbiter along with the propulsion system, AOCS, flight behaviour of the orbiter for atmospheric flight including the re-entry phase, thermal protection during re-entry, and crew member safety at the highest level in all phases of vehicle operation including launch abort. Results indicate a significant improvement in space utilization of the launch vehicle as the wings are housed inside the spacecraft during the launch phase. The autonomous flight controlled by on board computers and compatibility of the spacecraft for rendezvous and docking at the space station, possibly exploiting artificial intelligence further adds on to the benefits of this proposed design. The flaps and wings support the gliding re-entry capabilities, as well as landing experience of sensitive cargo and astronauts. The multidisciplinary optimisation results in spacecraft satisfying the mission requirements with reduced risks, low cost per launch, and more launches per year.