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MULTIDISCIPLINARY SHAPE OPTIMIZATION OF FUTURE REUSABLE SPACE VEHICLE

Abstract

The presence of human in the Low Earth Orbit requires frequent low-cost transportation of cargo and crew to Space Station. To improve the feasibility of space transportation from Earth to LEO, it's necessary to consider economically viable and re-usable space vehicle with autonomous capabilities, including enhanced low impact docking and improved re-entry capabilities. The objective is design of an aerodynamically modified space vehicle to meet the crewed and un-crewed mission requirements. The proposed orbiter design is a compact propulsive stage equipped with retractable wings and base flaps at the rear end. The retractable wings along with flaps will aid gliding re-entry of the vehicle. The retractable wings, initially housed inside the orbiter during the launch phase, so as to meet international launch vehicles guidelines, will be deployed after orbital insertion. The wings and the flaps will be actuated using advanced thermally protected electromagnetic actuators. The base flaps ensure maneuver during the atmospheric re-entry phase, becoming active when the efficiency of the control surfaces increases 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 decelerators after touchdown on any conventional runway. The orbiter's Attitude and Orbital Control System ensures to follow the optimized trajectory with required ΔV from the initial injection orbit to the ISS or future space station rendezvous orbit. The orbiter is capable to dock at the space station and will be equipped with highly compatible space docking ring which ensures the docking with multiple ports. Multidisciplinary shape optimization is performed to meet mission objectives, considering the selection of aerodynamic shape for wings, base flaps and orbiter along with the propulsion system, AOCS, flight behavior of the orbiter for atmospheric flight and re-entry phase, thermal protection during re-entry and crew member safety at the highest level in all phases of 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 and compatibility of the spacecraft to dock at ISS and future space stations further adds on to the benefits of the proposed design. The flaps and wings improve the gliding re-entry capabilities, as well as landing experience of sensitive cargo and astronauts. The multidisciplinary optimization results in spacecraft satisfying the mission requirements with low cost per launch.