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# RELIABILITY MODIFICATION IN MULTIDISCIPLINARY DESIGN OPTIMIZATION OF A SOLID PROPELLANT LAUNCH VEHICLE

**Abstract**

Multidisciplinary Design Optimization (MDO) approaches have significant effects on aerospace vehicle design methodology and in last decade non-deterministic MDO of aerospace vehicle has been considered. Reliability-base design is one of the non-deterministic approaches in which a design is sought that has a probability of failure that is less than some acceptable (invariably small) value. Needs for small satellite missions increase the potential of using small launch vehicles, Where Reusable Launch Vehicles (RLVs) don't have any opportunity for competition. Expendable Launch Vehicles (ELVs) were used over 50 years and their reliability has been demonstrated. Small Solid Propellant Expendable Launch Vehicles (SSPELVs) are cost beneficial and affordable so Reliability-base Multidisciplinary Design Optimization (RBMDO) of a two-stage SSPLV is investigated.In this study propulsion, weight, aerodynamic (geometry) and 3degree of freedom (3DOF) trajectory simulation disciplines are used in an appropriate combination. In the case of SSPELVs, propellant cost is significant thus; in this study, throw weight minimization was chosen as system performance index (objective function) for design optimization. Input parameters for propulsion code include motor diameter, propellant properties, combustion thermo-chemical characteristic, thrust and burning time. The code computes propellant weight, specific impulse, nozzle exhaust velocity, port and throat area, propellant burning area and motor dimensions. Propulsion module calculates propellant, weights. Inter-stage structure, payload adapter, fairing, and guidance-control set are estimated by statistical curve fitted mass estimate relationships. The aerodynamic code generates tabulated aerodynamics coefficients. These tables present coefficient values relative to Mach number, Reynolds number and angle of attack.Design variables are classified into three types. The variables represent geometric shapes of the vehicles (diameter of each stages), propulsion performance (thrust and burning time of solid rocket motors and parameters of flight trajectory (maximum angle of attack during first stage maneuver, final pitch angle and course time).Many constraints should be satisfied in the design of LVs. This study considers several constraints; include mission, stage fall down safety, structure, control system ability and available technology. After deterministic MDO process the first order reliability method is used to modify design to more reliable point. Results show that in new design point reliability is increased about 10 percent, while total mass is increased about 0.3 percent.