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Author: Mr. Florin Mingireanu
Romanian Space Agency (ROSA), Romania, florin.mingireanu@rosa.ro

Dr. Marius STOIA-DJESKA
University POLITEHNICA of Bucharest - Research Center for Aeronautics and Space, Romania, marius.stoia@gmail.com

OPTIMIZATION OF 2 STAGE BOOSTED DART SUBORBITAL VEHICLE

Abstract

The purpose of this work is to extend previous work performed by our research team in the area of boosted dart sounding vehicles as a means of exploring upper atmosphere. A 2 stage boosted dart sounding vehicle is considered and a full 6 DOF modeling is developed for this vehicle as a continuation to a previous ESA funded project. The 6 DOF numerical model is using a full quaternion formulation, rotating, non-spherical Earth model while the dart is considered to be inert and to carry the payload. Coupled with 6 DOF numerical model, a 0-D, erosive burning, interior ballistic model is developed in order to provide accurate results for the solid rocket motors to be used on the boosted dart vehicle. Both 6 DOF exterior ballistic model and the 0-D interior ballistic model use a Runge-Kutta order 4 numerical integration scheme. Due to simplicity requirement (which directly influences the cost of the vehicle) only hot separation technique is considered. A genetic optimization algorithm is used in order to find the optimum architecture of the 2 stage boosted dart vehicle. As a mission objective it is considered that a mass of 4 kg of payload (transported inside of the dart) is to be flown at 300 km altitude. The diameter of the dart is fixed to 50 mm while the overall length of the dart is fixed to 1 meter. The genetic optimization technique runs through all the exterior and interior ballistics parameters using an objective function that is to be minimized. For the solid propellant we considered the specific impulse to vary between 220 seconds and 270 seconds while the structure of the overall vehicle is considered to be high grade steel. For the solid propellant geometry we considered end-burning, tubular, star-shaped and finocyl propellant geometries; the study is limited to these geometries since, from a practical point of view, these are the geometries that we can also easily replicate for a practical implementation of the vehicle. We also limited the optimization study only to identical diameter solid rocket motors for both of the stages. One “winning” architecture is found and we propose the practical implementation with several considerations taken into account.