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A NEW PARADIGM FOR ENABLING PLANETARY CLASS MISSIONS ON NASA MIDEX BUDGETS

Abstract

Integrating one or two solid rocket motor (SRM)-based upper stages onto an existing medium class launch vehicle (LV) dramatically increases mass-to-orbit performance to a reference orbit relatively inexpensively. This paper explores the performance effect of specific combinations of Northrop Grumman (NG) STAR or Orion solid rocket motor upper stages integrated on top of a two stage NASA medium class LV. Major heritage exists integrating new upper stages onto existing LVs. Twice before, NG has integrated an SRM-based upper stage onto an existing NASA LV. This was first done on the New Horizons mission in 2004 and 2005, where a STAR 48 3rd stage was integrated onto an Atlas V LV for a January 19, 2006 launch to Pluto via Jupiter. In the second example, in 2016 and 2017, NG integrated a STAR 48 3rd stage onto a Delta IV Heavy for the 2018 August 18 Parker Solar Probe mission. Both launches were successful.

At least five NG SRM-upper stages are available to be used as either third or forth stages: the STAR 27, 37 and 48, and the Orion 50XL and 38. Target NASA LVs include the SpaceX Falcon 9, the United Launch Alliance (ULA) Vulcan, the Blue Origin New Glenn, and the NG Antares. The authors selected a reference orbit of Geosynchronous Transfer Orbit (GTO) to compute mass to orbit performance for the NASA LV portion of each launch, using the NASA Program to Optimize Selected Trajectories (POST). Each possible NASA LV and possible upper stage combination performance to a reference mission orbit of a direct transfer to Jupiter, with mass-to-orbit performance is also calculated using POST, and provided. The mass-to-orbit performance takes the form of the Maximum Possible Value (MPV) of the mass of an Observatory for each LV/upper stage combination for the direct Jupiter injection trajectory.

Cost savings by using this approach versus the cost of the required heavy lift LV to do a direct Jupiter injection are indicated. This approach to optimizing Design Reference LV mass-to-orbit performance enables planetary class missions on a NASA MIDdle EXplorer (MIDEX) $300M budget for the first time, with no advanced engineering development required.