

PEG Enhancement for EM1 and EM2+ Missions

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NASA is currently building the Space Launch System (SLS) Block-1 launch vehicle for the Exploration Mission 1 (EM-1) test flight. The next evolution of SLS, the Block-1B Exploration Mission 2 (EM-2), is currently being designed. The Block-1 and Block-1B vehicles will use the Powered Explicit Guidance (PEG) algorithm. Due to the relatively low thrust-to-weight ratio of the Exploration Upper Stage (EUS), certain enhancements to the Block-1 PEG algorithm are needed to perform Block-1B missions. In order to accommodate mission design for EM-2 and beyond, PEG has been significantly improved since its use on the Space Shuttle program. The current version of PEG has the ability to switch to different targets during Core Stage (CS) or EUS flight, and can automatically reconfigure for a single Engine Out (EO) scenario, loss of communication with the Launch Abort System (LAS), and Inertial Navigation System (INS) failure. The Thrust Factor (TF) algorithm uses measured state information in addition to a priori parameters, providing PEG with an improved estimate of propulsion information. This provides robustness against unknown or undetected engine failures. A loft parameter input allows LAS jettison while maximizing payload mass. The current PEG algorithm is now able to handle various classes of missions with burn arcs much longer than were seen in the shuttle program. These missions include targeting a circular LEO orbit with a low-thrust, long-burn-duration upper stage, targeting a highly eccentric Trans-Lunar Injection (TLI) orbit, targeting a disposal orbit using the low-thrust Reaction Control System (RCS), and targeting a hyperbolic orbit. This paper will describe the design and implementation of the TF algorithm, the strategy to handle EO in various flight regimes, algorithms to cover off-nominal conditions, and other enhancements to the Block-1 PEG algorithm. This paper illustrates challenges posed by the Block-1B vehicle, and results show that the improved PEG algorithm is capable for use on the SLS Block 1-B vehicle as part of the Guidance, Navigation, and Control System.