Coupled Solid Rocket Motor Ballistics and Trajectory Modeling for Higher Fidelity Launch Vehicle Design

Brett Ables

Multi-stage launch vehicles with solid rocket motors (SRMs) face design optimization challenges, especially when the mission scope changes frequently. Significant performance benefits can be realized if the solid rocket motors are optimized to the changing requirements. While SRMs represent a fixed performance at launch, rapid design iterations enable flexibility at design time, yielding significant performance gains.

The streamlining and integration of SRM design and analysis can be achieved with improved analysis tools. While powerful and versatile, the Solid Performance Program (SPP) is not conducive to rapid design iteration. Performing a design iteration with SPP and a trajectory solver is a labor intensive process. To enable a better workflow, SPP, the Program to Optimize Simulated Trajectories (POST), and the interfaces between them have been improved and automated, and a graphical user interface (GUI) has been developed. The GUI enables real-time visual feedback of grain and nozzle design inputs, enforces parameter dependencies, removes redundancies, and simplifies manipulation of SPP and POST's numerous options. Automating the analysis also simplifies batch analyses and trade studies. Finally, the GUI provides post-processing, visualization, and comparison of results. Wrapping legacy high-fidelity analysis codes with modern software provides the improved interface necessary to enable rapid coupled SRM ballistics and vehicle trajectory analysis.

Low cost trade studies demonstrate the sensitivities of flight performance metrics to propulsion characteristics. Incorporating high fidelity analysis from SPP into vehicle design reduces performance margins and improves reliability. By flying an SRM designed with the same assumptions as the rest of the vehicle, accurate comparisons can be made between competing architectures. In summary, this flexible workflow is a critical component to designing a versatile launch vehicle model that can accommodate a volatile mission scope.