SUPERSONIC RETRO-PROPULSION FLIGHT TEST CONCEPTS

Ethan Post[(1)], Artem Dyakonov[(2)], Ashley Korzun[(3)], Ian Dupzyk[(4)], Jeremy Shidner[(5)], Arturo Casillas[(6)], Karl Edquist[(7)]

[(1)]Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA, 91109, USA, Email: ethan.a.post@jpl.nasa.gov
[(2)]NASA Langley Research Center, Hampton, VA, 23681, USA, Email: artem.a.dyakonov@nasa.gov
[(3)]Georgia Institute of Technology, 270 Ferst Drive, Atlanta, GA, 30332, USA, Email: akorzun@gatech.edu
[(4)]NASA Ames Research Center, Moffett Field, CA, 94035, USA, Email: ian.c.dupzyk@nasa.gov
[(5)]NASA Langley Research Center, Hampton, VA, 23681, USA, Email: jeremy.d.shidner@nasa.gov
[(6)]Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA, 91109, USA, Email: arturo.r.casillas@jpl.nasa.gov
[(7)]NASA Langley Research Center, Hampton, VA, 23681, USA, Email: karl.t.edquist@nasa.gov

Supersonic retro-propulsion (SRP) is an advanced entry, descent, and landing (EDL) supersonic decelerator technology that, if developed, could significantly increase landed mass capabilities at Mars. In the development of future mission concepts, NASA has recognized the need for advanced EDL systems, and the Agency has begun targeted funding for SRP technology development. SRP has been assessed to currently be at Technology Readiness Level (TRL) 2, "Technology concept and/or application formulated". A roadmap has been developed for the maturation of SRP to TRL 6, at which point SRP is likely considered to be sufficiently mature for incorporation into a flight project. Wind tunnel testing, systems analysis, and computational fluid dynamics simulation efforts are under way. The work contained herein represents a focused effort to define Earth-based SRP flight testing concepts. These concepts compliment ground testing and analytical efforts and will play a critical role in the maturation of SRP to a viable flight system.

Two sub-scale flight test concepts, both designed for launch on sounding rockets, are considered in detail for potential proof-of-concept testing of the SRP technology. The flight test is intended to demonstrate successful operation, from initiation through nominal operation, of a "hot" SRP system at conditions that replicate the relevant physics of the aerodynamic-propulsive interactions expected in flight. Major subsystem components sufficient to close a preliminary design are defined for each flight test concept, including: mechanical, propulsion, instrumentation, telecommunications, avionics, and power. Commercial, off-the-shelf components are utilized as much as possible in both concepts. Trajectory designs and analyses are performed to understand and optimize test conditions and vehicle parameters including thrust profile and initiation altitude.

The analysis and design approach used to develop these flight test concepts are discussed in detail in this paper. Following definition of a set of flight test objectives and a set of mission-level requirements, preliminary trajectory analyses were completed. These analyses assumed a sounding rocket platform due to a relative low cost and complexity as compared to alternative flight testing platforms. The results of these analyses indicated that a flight test vehicle capable of meeting mission-level requirements could be designed for launch on a sounding rocket, leading to the development of two point designs. These point designs provide more accurate mass distribution and thrust profile estimates than those used in the preliminary trajectory analyses. The mass estimates were found to be within payload mass limits of a Terrier-Improved Orion sounding rocket. Further analyses are planned that will advance the most favorable concepts to a higher maturity level in preparation for a proposal as a part of a flight test program.

Both sounding rocket-based flight test concepts were found to represent viable options for SRP flight tests in that they: (1) demonstrate an SRP proof-of-concept in a flight environment, (2) replicate relevant SRP physics using a minimally integrated system, (3) collect data during flight within acceptable uncertainties to satisfy relevant TRL 5 achievement criteria, (4) demonstrate the ability to design, package, integrate, and test SRP subsystems, and (5) become a stepping stone to the more complex flight tests that will follow and reduce the associated risks.