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DESIGN OF A ROCKET-POWERED TRANSONIC RESEARCH VEHICLE

Abstract

The TRV-1 is a transonic research vehicle project that was set up to design, manufacture, and test-fly a separation mechanism at transonic velocities, in a Shuttle-like side motor-glider configuration. This project was carried out by a group of Delft Aerospace Rocket Engineering (DARE) students.

Rocket stage separation often occurs immediately following the first stage motor burn-out, thus usually at high dynamic pressures in the transonic or supersonic velocity range. In this range, various shock-wave phenomena result in high drag and control problems due to flow separation at control surfaces. In order to investigate these phenomena, the TRV-1 (Transonic Research Vehicle-1) project was set up within DARE (Delft Aerospace Rocket Engineering), TU Delft's student rocketry team.

The goal of the TRV-1 project was to design and test-fly a separation mechanism for a Shuttle-like booster-rocketplane configuration (modeled as a half-scale of an existing hypersonic research vehicle project). The separation system is to decouple the glider from a large side-booster within the velocity range of Mach 1.4 to 2.0, with a reaction time of less than 0.5 seconds. The means to achieve this is through accelerating TRV-1 by means of a solid rocket motor to a velocity of Mach 2.0 in vertical flight and triggering the release mechanism, then through measurements verifying that it had worked within the allotted time frame.

The TRV-1 system consists of two main subsystems: the transfer vehicle Leonidas-5 (consisting of a monocoque solid rocket motor—nosecone—stabilizing surface structure) and the glider system, connected to the transfer vehicle via the separation mechanism. The glider system is unpowered and houses the electronics, parachute recovery system, plus an additional scientific payload. The ground segment of the TRV-1 consists of the launch tower and flight control. The TRV-1 full configuration (transfer vehicle coupled with glider) is passively stabilized. Its launch is planned for October 2015.

This paper details the design, manufacturing, and testing process of the TRV-1, starting from the mission design and detailing the various subsystem design, simulations, and validation of those simulations through testing. Specifically, the design process of the solid rocket motor, separation system, glider manufacturing, and overall system assembly and integration are included, along with the results of the test campaigns which validated the simulations and contributed to the results of the design process.