The Hy-V Scramjet Flight Experiment

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A university program has recently been initiated with the goal of flying a dual-mode scramjet at Mach 5 using a sounding rocket launched from NASA Wallops Flight Facility. The experiment will be focused on isolating the effects of ground facilities and facility vitiation on scramjet mode-transition. Based on undergraduate and graduate student involvement in the proposed research, NASA Wallops is supplying the sounding rocket and launch range support. The flight experiment will be supported by and preceded with university wind tunnel experiments. The wind tunnel research will include dual-mode scramjet mode-transition experiments in clean-air and vitiated facilities. The combined flight and ground database will enable vitiation and facility effects to be fully isolated and the database will be used for numerical model development. This paper presents an overview of the program, current status and future plans.

I. Introduction

The development of propulsion technology for many air-breathing hypersonic systems is critically dependent on the availability of accurate predictive tools for the Dual-Mode Scramjet (DMSJ) cycle. This is because the DMSJ is expected to be a core technology of new reusable and reliable launch systems for civil space access[1,2], as well as in military systems for responsive space lift and rapid global force projection[3]. Even if the underlying physics is adequately captured, the accuracy of these predictive tools can only be quantified through validation against empirical databases. Therefore, the validated accuracy of these methods not only depends on the physical modeling, but also on the accuracy and comprehensiveness of the empirical databases. Such databases can be generated by both ground and flight experiments. Ground experiments suffer from facility induced effects, such as vitiation, flow quality and poorly matched boundary conditions. Conversely, flight experiments don't include facility effects, but due to the nature of available diagnostics, often result in more limited databases than ground experiments. Flight experiments are also typically more expensive than ground based experiments. Therefore, ground and flight databases must both be used in the development of predictive tools, and combined, the inadequacies of each can be identified such that their contribution to predictive tool uncertainties is limited. Further, the cost effectiveness of this approach can be preserved by targeting investment at comprehensive ground based experiments and at a limited number of complementary flight experiments.

In order to generate a comprehensive ground and flight based DMSJ database for predictive tool development and accuracy quantification, and simultaneously identify database inadequacies, a low-cost flight experiment of a generic unit scramjet combustor is being undertaken. This experiment will be conducted at a flight Mach number of 5 and will take place in captive carry mode aboard a sounding rocket launched from NASA Wallops. The experiment will focus on the scramjet/ramjet propulsion mechanism of mode-transition that typically takes place in a DMSJ near a flight Mach number of 5. The generated database will then be combined with data obtained from a parallel ground test effort. This activity will involve multiple vitiated and unvitiated ground test facilities. The combined database will enable vitiation and facility effects to be fully isolated and will be used for advanced numerical and analytic model development. In the course of the flight experiment, engine-unstart, control margins/constraints and performance will also be examined.

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