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TECHNOLOGY NEEDS FOR SINGLE STAGE TO ORBIT PROPULSION

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INTRODUCTION

Propulsion Technologies

NASA's Reusable Launch Vehicle (RLV) Propulsion Technologies Program includes maturation and demonstration activities supporting a variety of propulsion system concepts. The primary emphasis of this program is to identify and mature the technologies required to enable the development of the optimum main propulsion system (MPS) for RLV applications. By applying a methodical approach to the maturation process, through use of subscale system and subsystem validation testing and, where appropriate, engine system level technology demonstrations, the development cost of the RLV MPS will be substantially reduced. The major building blocks of this approach are Engine Systems and MPS Subsystem Demonstrators, Supporting Component Technologies, and Russian Technologies, and are described below.

PROGRAM SPECIFICS

Engine Systems and MPS Subsystem Demonstrators

The key technology capability that historically has not been demonstrated prior to concept selection has consistently been the engine system. Demonstration of key technologies at the engine system and MPS subsystem level will provide the understanding required to make an informed concept selection prior to initiation of the full-scale development of the engine system. Adequate system-level technology demonstration will greatly reduce the cost and risk of the development program.

Engine Systems

Operability is one of the most critical requirements for an RLV propulsion system. Test-bed engines provide a cost effective, practical approach to 1) the development of operability schemes, 2) a means for exploration of engine control concepts, and 3) a tool for the exploration of system simplification. In addition, the demonstration engine concept provides the capability to generate an improved set of derived requirements - individual component requirements, engine system requirements, and operability requirements. The test-bed engine system will permit extrapolation of requirements from demonstrated conditions to the desired design point. Combined with the other technology demonstrations, this process will develop design data bases, correlate test data with predictions, and anchor analysis models and codes. The most promising engine system concepts are included in the initial phase of the demonstration program, which includes the SSME-derived bell annular tripropellant engine and the Russian RD-0120 derived tripropellant engine.

Subscale MPS Test-Bed

The primary function of the subscale MPS test-bed is to assess the capability of competing MPS concepts to meet performance and operability requirements of the RLV program. The ability to assess propulsion system integration issues early in the design/development process is key to controlling costs. In addition, accurate definition of derived requirements is critical to the successful execution of the full-scale development program. The subscale MPS subsystems test-bed will permit extrapolation of requirements from demonstrated conditions to the desired design point.

Integrated Propulsion System Test-Bed

A subscale integrated propulsion systems test-bed will assess the capability of a fully functional, integrated RLV propulsion system to achieve the desired performance and operability goals. The demonstrator consists of RP-1, LO_2, and LH_2 tanks, propellant feed system, pressurization system, propellant loading system, propellant conditioning system, vehicle health management, tank support structure, and thrust structure. These components are installed into a fully integrated ground test facility which will provide maximum flexibility for testing advanced system components.

Integrated Auxiliary Propulsion System Test-Bed

One key approach toward implementing operability into the propulsion system design is to use common propellants (O_2/H_2) for all propulsion and power functions on the vehicle; including the main propulsion, auxiliary propulsion and reaction control thrusters, auxiliary power unit (APU), thermal control system, and fuel cells. A liquid/gas conversion (LGC) system will be designed and built to take the LO_2/LH_2 from the main propellant tanks, pressurize and vaporize the cryogen to warm high-pressure gas, and supply the RCS thrusters. An LGC system, compared to an all-gas RCS, will provide a significant weight/volume savings. A Russian O_2/H_2 APU will provide the needed hydraulic power without penalizing the main engine power balance. The propellant conditioning LGC subsystem and the APU will be integrated into a workhorse pallet which will be fully tested for function, operability, and performance in preparation for future integration into the Delta Clipper-Experimental Advanced (DC-XA) demonstrator vehicle for ground/flight testing that will serve to further mature these technologies.

Supporting Component Technologies

The primary objective of the RLV Propulsion Technology Program is the maturation and demonstration of engine system and MPS subsystem technologies. However, there are additional component technologies that support the LO_2/LH_2 and LO_2/LH_2/RP-1 engine system concepts that require early technology development. These technologies include the demonstration of the performance and manufacturing processes of modular combustion chamber concepts and design, fabrication, and testing of oxidizer-rich LO_2/LH_2 preburners, oxidizer-rich LO_2/RP-1 preburners, and testing of candidate turbine drive system materials.

Russian Technologies

Recent data on the technological capabilities of the former Soviet Union are being evaluated for application in the RLV Program. The Russian propulsion systems make extensive use of oxygen rich combustion to improve the efficiency of their engines. The transfer and understanding of this technology could provide significant returns for successful incorporation into U.S. propulsion systems. In addition to the oxygen-rich technologies, there are Russian manufacturing methods/techniques and materials that have been evaluated and selected for inclusion in the initial phase of the RLV Program. In addition to existing technology, the Russians are currently working on development of a tripropellant derivative of the venerable RD-0170 engine.