About Propulsion

Description

The Propulsion Office supports all propulsion design elements of the SLI Program through studies, design, manufacture, analysis, and test of advanced propulsion systems and subsystems. Propulsion development efforts include multiple prototype booster-class main engine designs, non-toxic reaction control thrusters, crew-escape propulsion, jet-powered first stage fly-back propulsion, and non-toxic propellant studies.

Purpose

Designing advanced propulsion systems and hardware that demonstrate greater reliability, safer operations, and less expensive maintenance and production costs will enable successful integration of new propulsion systems with competing flight architecture requirements. This risk-reduction work supports a full-scale development decision in 2006.

Mission Success Criteria

The Propulsion Office measures success by its ability to enable the SLI Program goals of safe, reliable, and affordable space transportation by meeting the following objectives:

- Demonstrate significantly improved propulsion systems safety, reliability, and operations cost
- Provide a credible basis for estimates for flight systems development
- Reduce the technical and programmatic risks of developing prototype propulsion flight hardware

Tasks/Approach

The Propulsion Office manages the following five Propulsion Projects:

- Alpha Main Engine Project - Developing a large liquid oxygen/liquid hydrogen (LOX/LH2) staged combustion prototype main engine design, two large liquid oxygen/kerosene (LOX/RP) staged combustion prototype main engine designs, and an Integrated Powerhead Demonstrator (IPD)
- On-Orbit Propulsion Systems Project - Managing all upper stage propulsion activities and all cryogenic auxiliary propulsion activities, including reaction control and on-orbit maneuvering systems, as well as all non-toxic hydrogen peroxide propellant studies
- Propulsion Systems Project - Managing the Air Collection Enrichment Study (ACES) and propellant crossfeed system. In addition, the Propulsion Systems Project is responsible for overall propulsion integration with the architecture by chairing and leading the Propulsion Systems Integration Group (PSIG)
- Crew-Escape and Survival Propulsion Project - Managing the risk reduction efforts for new crew escape propulsion systems, including solid, liquid, and hybrid propellant technology

- Booster Jet Propulsion Project - Reducing the risks of a jet-powered first stage engine capable of flying the booster stage back to the original launch site or alternate launch site

Contractors

- Rocketdyne Propulsion and Power, Seal Beach, CA
- TRW, Redondo Beach, CA
- Aerojet, Sacramento, CA
- Pratt & Whitney, West Palm Beach, FL

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Alpha Main Engine Project

Description

The Alpha Main Engine (AME) Project is responsible for studies, design, manufacturing, analysis, and test of developing a large LOX/LH2 staged combustion prototype main engine design; two large LOX/RP staged combustion prototype main engine designs, and an Integrated Powerhead Demonstrator (IPD). The Project manages the following designs:

- **RS-83 Main Engine** - LOX/LH2
- **RS-84 Main Engine** - LOX/RP
- **TR107 Main Engine** - LOX/RP
- **IPD** - Main engine system demonstrator

Purpose

AME will reduce the risk associated with developing large booster class liquid rocket engines and an IPD for use in the 2nd Generation RLV. This risk reduction includes the design, analysis, manufacture, and testing of components, which will ultimately lead to the manufacture and hot-fire testing of prototype engines.

This Project will increase the technology base relative to achieving high reliabilities, lower cost, and high-performance liquid rocket engines. In addition, the AME will develop the technologies required for optimizing a full-scale development (FSD) engine system.

Goals

- Support architecture safety and reliability goals
- Support architecture operations cost goal
- Conduct successful prototype engine Critical Design Review (CDR) in 2003
- Complete the Project within budget and on schedule
- Enable successful prototype engine tests in the 2005-2006 timeframe
- Define a comprehensive preventative maintenance program that allows for easier maintenance, lowers cost and turnaround time, and provides greater engine availability
- Assure that the derived flight engines meet safety and fault tolerance requirements defined in East/West Range Requirements (EWR) 127-1

Contractors
- Boeing Rocketdyne, Seal Beach, CA
- TRW, Los Angeles, CA
- U.S Air Force

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RS-83

Description

The RS-83 main engine uses a high-efficiency LOX/LH2, fuel-rich staged combustion (FRSC) engine cycle designed by Rocketdyne. The RS-83 is the product of an intense study and is designed to meet the demanding requirements of the 2nd Generation RLV Program's cost, reliability, and safety goals.

The RS-83 main engine is a high-fidelity prototype engine. A prototype engine is a continuum from technology test-bed to operational flight that yields a set of attributes traceable to the reference flight engine.

Purpose

The RS-83 Main Engine Project reduces the risks associated with the development of a large booster class liquid rocket engine system for use in the 2nd Generation RLV. This risk reduction includes the design, analysis, manufacture, and testing of components, which will ultimately lead to the development of a prototype engine.

This Project will increase the technology base relative to achieving high reliability, lower cost, and strong performance liquid rocket engines. Additionally, the Project will develop the technology required for optimizing a full-scale development (FSD) engine system.

The RS-83 main engine simplifies the engine system design using the following elements:

- A single preburner for eased control constraints
- Series turbines to substantially reduce turbine inlet temperatures
- Series Main Combustion Chamber (MCC)/nozzle coolant circuit to decouple it from the preburner and reduce turbine temperature spikes at the start

Using these simplified design methods with the FRSC cycle reduces the number of catastrophic failure modes and helps satisfy the SLI Program's safety and reliability goals. Using simplified components lowers production and operating costs.

Mission Success Criteria

The success of the RS-83 Project is measured by successful completion of a System Requirements Review (SRR), a System Definition Review (SDR), a Preliminary Design Review (PDR), and a Critical Design Review (CDR) of the complete engine system.

The engine system includes the following key technologies, which are crucial risk mitigation activities:

- Electro Mechanical Actuator (EMA) Valves
- Hydrogen compatible materials
- Liquid - liquid preburner
- Engine Health Management (EHM) systems
- Turbine Damping
- Inducer performance
- Hydrostatic Bearings

Contractor

- Boeing/Rocketdyne, Los Angeles, CA

Project Manager

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RS-84

Description

The RS-83 main engine uses a high-efficiency LOX/LH2, fuel-rich staged combustion (FRSC) engine cycle designed by Rocketdyne. The RS-83 is the product of an intense study and is designed to meet the demanding requirements of the 2nd Generation RLV Program's cost, reliability, and safety goals.

The RS-83 main engine is a high-fidelity prototype engine. A prototype engine is a continuum from technology test-bed to operational flight that yields a set of attributes traceable to the reference flight engine.

Purpose

The RS-83 Main Engine Project reduces the risks associated with the development of a large booster class liquid rocket engine system for use in the 2nd Generation RLV. This risk reduction includes the design, analysis, manufacture, and testing of components, which will ultimately lead to the development of a prototype engine.

This Project will increase the technology base relative to achieving high reliability, lower cost, and strong performance liquid rocket engines. Additionally, the Project will develop the technology required for optimizing a full-scale development (FSD) engine system.

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- Liquid - liquid preburner
- Engine Health Management (EHM) systems
- Turbine Damping
- Inducer performance
- Hydrostatic Bearings

Contractor

- Boeing/Rocketdyne, Los Angeles, CA

Project Manager

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TR107

Description

The SLI TR107 is a liquid oxygen and hydrocarbon (LOX/RP) engine that operates on an oxidizer-rich staged combustion (ORSC) cycle in the 1 Mlbf class. The TR107 demonstrates key technologies needed to reduce the risk of 2nd Generation RLV development.

Purpose

The TR107 task matures the concept design of the 1 Mlbf LOX/RP main engine in parallel to the requirements of the vehicle architectures. During development, the TR107 task defines parameters that need to flow up to the vehicle requirement system, such as:

- Engine reliability
- Failure modes
- Control and health management plans
- Engine cost and weight
- Operational and maintenance costs.

Objectives

The TR107 enables the 2nd Generation RLV goals of greater reliability and operability by minimizing parts count and lowering cycle pressures to extend the lifetime of parts. The enabling technologies include:

- A duct-cooled main chamber
- A pintle preburner injector
- Materials that do not require coatings for the oxidizer-rich environment

Approach

The SLI Propulsion Office's Alpha Main Engine Project manages the TR107.

Contractor

- TRW, Los Angeles, CA

Project Manager

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Integrated Powerhead Demonstrator

Description

The Integrated Powerhead Demonstrator (IPD) is a joint Project between NASA and the U.S. Air Force to design, fabricate, and test a 250 klbf demonstrator brassboard rocket engine. For the SLI 2nd Generation RLV, the IPD supplies a timely risk mitigation demonstration of component technologies that are common between IPD and the main engines being considered for full-scale development by SLI. These include technologies being considered directly for RS-83 and RS-84. Additionally, the IPD information is being requested by the TR107 Project.

History

The U.S. Air Force Research Laboratory (AFRL) initiated the IPD Project in August 1994. The requirements were to demonstrate a set of preburners and turbopumps applicable to a 250 KLbf engine system that had the following requirements:

- Designed to minimize life cycle cost
- A LOX/LH2 system capable of continuous engine throttling from 20% to 100% of the rated power level (RPL)

Boeing/Rocketdyne was selected to develop and test the high-pressure turbopumps. Aerojet was selected to develop the full-flow cycle preburners.

In 1996, AFRL added program scope to develop a complete engine system. Boeing/Rocketdyne was selected to provide the Special Test Equipment (STE) elements of a main injector/powerhead and the engine system. Aerojet was selected to provide the STE elements for the main combustion chamber and the nozzle.

In late 1999, MSFC agreed to support the IPD Project under the Advanced Space Transportation Program (ASTP). In 2001, the MSFC portion of the IPD Project became a part of SLI.
In 2000, the requirement for throttling from 20% to 100% RPL was changed from 50% to 100% RPL to better reflect the perceived needs of SLI.

Purpose

The IPD Project will demonstrate the benefits of the full-flow staged combustion (FFSC) engine cycle for the joint DoD and NASA Integrated High Payoff Rocket Propulsion Technology (IHPRPT) program. In addition, the Project provides timely risk mitigation demonstration of component technologies that are common between IPD and the main engines being considered for full-scale development (FSD) by SLI.

Objectives

- Demonstrate the ability of the engine system to meet the Phase I IHPRPT goals
- Provide SLI prototype main engine contractors with timely information on key technology items
- Demonstrate the benefits of the FFSC cycle

Key Technologies

- Hydrostatic bearings in LOX and LH2
- Clutching bearings
- Channel wall nozzles
- Large platelet main combustion chambers with blanch shields
- Oxygen rich turbine design technology

Technical Summary

The IPD engine design features the following elements:

- Full-flow staged combustion cycle operating at 250 klbf sea level thrust
- Continuous engine operation from 50% RPL to 100% RPL
- Main chamber pressure of 3000 psi at RPL with a nominal mix ratio of 6.7
- A hydrogen-rich preburner and an oxygen-rich preburner

In the FFSC cycle, all of the propellants that enter the engine are raised to high pressure by the turbopumps and are then passed through the preburners. This gas is then fed into the low-pressure ratio turbines on the two turbopumps. The turbine exhaust passes into the unique gas-gas main injector that feeds the combustion chamber.

Approach

The IPD has an integrated project management structure with the Project Manager (PM) and contractual control remaining at AFRL, while MSFC supplies a Deputy Project Manager to assist the PM with Project control. MSFC is the implementing technical organization, contributing the lead system engineer and appropriate technical insight personnel.

Contractors

- Boeing/Rocketdyne, Los Angeles, CA
- Aerojet, Sacramento, CA

Project Manager

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On-Orbit Propulsion Systems

Description

The SLI On-Orbit Propulsion Systems Project focuses on advanced technology development and risk reduction in the areas of on-orbit and auxiliary propulsion systems (APS). This Project is one of several managed within the SLI Propulsion Office.

Current content reflects the high priority risk reduction efforts required by 2nd Generation RLV architectures. Project content was modified based on updated risk reduction requirements identified during the Interim Architecture and Technology Review (IATR).

The IATR was concluded in March 2002 to coincide with the end of the base period of performance of contracts awarded under the NRA 8-30 Cycle I contracts. Based on results of the IATR, selected contract options were exercised, and others were not.

Following IATR, the SLI Propulsion Office was subsequently reorganized to support overall 2nd Generation RLV Program goals. As a result of this reorganization, elements of the Upper Stages and the Main Propulsion/Auxiliary Propulsion (MPS/APS) Projects were combined to form the On-Orbit Propulsion Systems Project.

This Project includes risk reduction activities for the following elements:

- Reaction Control Systems (RCS) Engine
- Orbital Maneuvering Systems (OMS)
- Non-toxic Hydrogen Peroxide Components
- Cryogenic Fluid Management Systems
- Upper Stage Engine

Purpose

The On-Orbit Propulsion Systems Project enables the 2nd Generation RLV Program propulsion technologies through advanced development and risk reduction.

This Project is not currently developing a flight propulsion system, but is performing advanced development on system components and subsystems identified as high risk. These development activities are intended to reduce the risk associated with On-Orbit Propulsion elements, allowing the Program make an architecture-level full-scale development (FSD) decision in 2006 that will result in a 2nd Generation RLV that is safer, more reliable, and more affordable.

Goals and Objectives

- Develop on-orbit systems technologies that reduce risks for candidate 2nd Generation RLV architectures
- Demonstrate significantly improved on-orbit propulsion systems safety, operability, and reliability
- Demonstrate operation of dual thrust RCS engines with safe, operable, non-toxic propellants
- Develop hydrogen peroxide-based propulsion system components and subsystems
- Assess an upper stage engine
- Reduce the technical and programmatic risks for on-orbit propulsion systems flight hardware development
- Provide high-fidelity basis for estimates of fight systems development costs
- Develop and test prototype on-orbit propulsion systems hardware
- Support the vehicle architecture safety, reliability, and cost goals through the use of non-toxic RCS propellant systems
- Complete the Project within budget and on schedule

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