2nd Generation Reusable Launch Vehicle
NASA Led Propulsion Tasks

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Space Transportation Technology Workshop
Agenda

- 2nd Generation RLV Propulsion Project
- Overview of NASA Led Tasks in Propulsion
- Gen2 Turbo Machinery Technology Demonstrator
- Combustion Devices Test Bed
- GRCop-84 Sheet For Combustion Chambers, Nozzles And Large Actively Cooled Structures
The Propulsion Project has been formulated to reduce risk in support of a Full Scale Development decision as early as 2005.

Propulsion Project includes the following elements for Earth-to-Orbit Launch Vehicles:
- Main Engine
- Main Propulsion System
- Auxiliary Propulsion Systems

Cryogenic Upper Stage Propulsion is included in the Propulsion Project.

2nd Generation RLV Propulsion Project
The 2nd Generation RLV Program Has Provided for NASA-Led Tasks within the Projects

‘Gated’ Selection Approach

- Gate 1
  - Does task address the Program Goals
    - Contribute to the safety and cost goals
- Gate 2
  - Is task appropriate for NASA to lead
    - Gov’t can do it better and cheaper than anyone else
    - If the Gov’t doesn’t do it, it won’t get done
    - Cross-cutting ... supports multiple architectures
- Gate 3
  - Does it need immediate start
    - Loss of a unique and necessary capability if not funded.
    - Schedule supports TRL6 by 05 ... OR
    - Task is needed to support the 2 year Program focusing

Only Tasks That Passed All Three Gates Were Selected

The Propulsion Project Has Selected Eight Tasks for Execution in FY01.

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Final Selection Process
This Session Will Provide Information on Each of the NASA-Led Tasks Selected by the Propulsion Project

Summarized by Introduction

- Large Composite Valve Technology
- Actively Cooled Ceramic Matrix Composite Nozzle RampLOX/H2
- Smart Leak Sensor
- Test of Large Scale Liquid Hydrogen Propellant Densification Hardware
- Full Flow Staged Combustion Injectors

Presentations Following Introduction

- GRCop-84 Sheet For Combustion Chambers, Nozzles And Large Actively Cooled Structures
- Combustion Devices Test Bed
- Gen2 Turbo Machinery Technology Demonstrator

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Funded Task List for Propulsion
Products
- Stand-alone Leak Detection System With a Surface Area the Size of Postage Stamp
- Detection of Both Fuel and Oxygen at the Same Time
- Integrated Signal Conditioning, Data Storage, Power, and Telemetry

Benefits
- Fundamental Need for Gen II vehicle for increased vehicle safety, increased reliability and maintainability, Reduced testing time and costs,

Customers
- Any 2nd Gen Vehicle

Unique / Enabling and Enhancing

Current State of the Art
- Hydrogen sensor Shuttle-tested
- Oxygen/Hydrocarbon sensors under development
- Prototype hydrogen/oxygen sensor system fabricated with limited miniaturization of electronics

Performance Metrics
- 20x decrease in individual sensor system size over present Shuttle tested technology/10x increase of sensor coverage
- Reduction in Maintenance Time and Costs by an order of magnitude

Risks
- Technology readiness of hydrocarbon sensor

USG Participants
- GRC (Lead Center), KSC, Make Engineering, Case Western Reserve University

Miniaturized Smart Leak Sensor System
Products
- Validation of LH2 densification process at large scale (TRL=6)
- Operable (portable) densification skid available for flight experiment or engine test program

Benefits
- Densification can reduce vehicle weight significantly (RLV studies showed ~18% weight reduction)

Customers
- Multiple STAS vehicles utilize densified LH2

Current State of the Art
- TRL 5, Small Breadboard Densification Unit tested in 1996=>30°C LH2; X-33 scale unit fabricated and in storage

Performance Metrics
- 8 lbs/sec LH2 densification rate from 37°C to 27°C
- Demonstrate recirculation tank loading process (thermal stratification)

Risks
- SOA 4-stage compressor performance

USG Participants
- GRC lead

Test of Large Scale LH2 Densification Hardware
**Current State of the Art**
- Small PMC valve built for DC-XA vehicle
- No large composite valves built

**Performance Metrics**
- Demonstrate a composite valve can be built and meet Shuttle requirements while at the same time reduce weight

**Risks**
- Composite parts and assembly do not meet Shuttle requirements.

**USG Participants**
- MSFC (Lead center), JSC

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**Products**
- A large diameter LH2 valve made from PMC material.
- A series of protective coatings that can be applied to composites and be used in a cryogenic environment. These coatings will increase the materials damage resistance.

**Benefits**
- The composite valve technology will enable weight reduction of large MPS components on a vehicle.
- The coating technology will enable the program to operate at a higher confidence level since the risks of impact damage are greatly reduced.

**Customers**
- Second Generation Program, Shuttle, Aerospace Industry

**Cross-Cutting Benefits**
- Lightweight components are applicable to all present and future launch vehicles.

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**Large Composite Valve Technology**

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- Complete testing of composite piece parts and off-the-shelf coatings
- Complete testing of valve assay, and development of new coatings
- Full scale demonstration on an MPS
- **Current State-of-the-Art (SOTA)**
  - No other concepts existing or in development capable of meeting nozzle ramp requirements
  - These NASA-Funded concepts represent the SOTA
- **Performance Metrics**
  - Areal weight requirement is 2.0 lb/ft² with a goal of 1.5 lb/ft² for the heat exchanger
- **Risks**
  - Aggressive development schedule
  - Manufacturing scale-up to flight design (industry task)
- **USG participants**
  - MSFC (lead Center), LaRC, GRC, AFRL/ML

- **Products**
  - Design level mechanical, physical, and thermal property database
  - Test validated thermal and thermostructural models
  - Demonstrated thermal performance and ability to contain high pressure hydrogen
  - Demonstrated manufacturing scale-up and manifolding

- **Benefits**
  - Potential performance, operability, and safety pay-offs for high temperature capability
  - CMC materials are high
  - Strength-to-weight of advanced CMCs at high temperature may provide a significant weight reduction at far aft end of vehicle where benefit is needed
  - High use temperature of CMCs provides additional temperature margin for uncooled reentry
  - High temperature capability expected to increase safety margins and allow significant simplification of aerospike engine features required for engine-out operation

- **Customers**
  - Primary industry customer, Lockheed Martin, has identified a wide variety of vehicles that would benefit from this technology including SSTO, TSTO, Shuttle Derived, CRV, CTV, and LFBB concepts
  - 3rd Generation RLV and all Rocket Based Combined Cycle (RBCC) propulsion concepts

- **This project is essential to maintain viable technology development schedule consistent with 2nd Generation RLV**
**Products**
- Optimized MCC injector concept that fully meets Gen 2 operability, life and performance goals (timed to support concept downselect)
- Optimized MCC injector concept(s) that exceed Gen2 requirements
- Experience in design and operation of LOX-rich preburners
- Seamless injector design package with tools validated to TL RL 6-can be used to calculate environments for tie predictions

**Benefits**
- High performing injectors with manageable heat fluxes
- Lower part count that increases reliability and lowers costs

**Customers**
- Injector Element Concepts-2nd Generation RLV (FFSC cycle)
- Injector Design Package- all projected 2nd Generation RLV cycles, 3rd Gen and SSME

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**Current State of the Art**
- Limited data base and empirical design methodologies create high-risk designs

**Performance Metric**
- Increase reliability by reducing part count (10x) and lowering heat fluxes (30%)
- Decrease injector development cost (2x), ops cost (2x) and weight (20%)

**Risks**
- Tight schedule to complete portions of task before cycle down-select

**USG Participants:** MSFC (Lead)/GRC

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**Full Flow Staged Combustion Cycle Injectors**