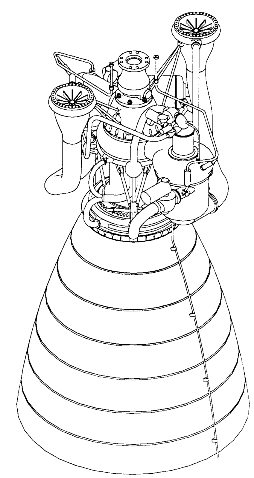
Advanced All Rocket System

Space Propulsion Technology
Assessment Workshop

April 2001

Summary Description
Long Life, High Thrust/Weight O_2/H_2 Rocket Engine

- High Performance Engine Designed Specifically for Long Life and Minimum Maintenance
- Optimized for the SSTO Mission
- Uses Full Flow Staged Combustion Cycle (FFSCC)to Greatly Improve Margins and Decrease Internal Environments
  - Greatly Increased Trade Space for Development
- Moderate Use of New Materials to Eliminate Need of Coatings and for O_2 Compatibility
- Result is Moderately High Thrust/Weight, Long Life Engine



- Sea Level Thrust, lbf 421,000
- Vacuum Thrust, lbf 484,585
- Nozzle Exit Pressure, psi 4.5
- Area Ratio 70
- Propellants O_2/H_2
- Mixture Ratio, O/F 6.9
- Power Cycle Full Flow Staged Combustion
- Turbine Temperatures
  - Ox Rich, ÞR 1,100
  - Fuel Rich, ÞR 1,150
- Chamber Pressure, psi 4,000
- Seal Level Specific Impulse, sec 392.2
- Vacuum Specific Impulse, sec @ 6.9 MR 451.4
  @ 6.0 MR 456.4
- Sea Level Engine Thrust/Weight 92
- Regen Cooled Bell Nozzle

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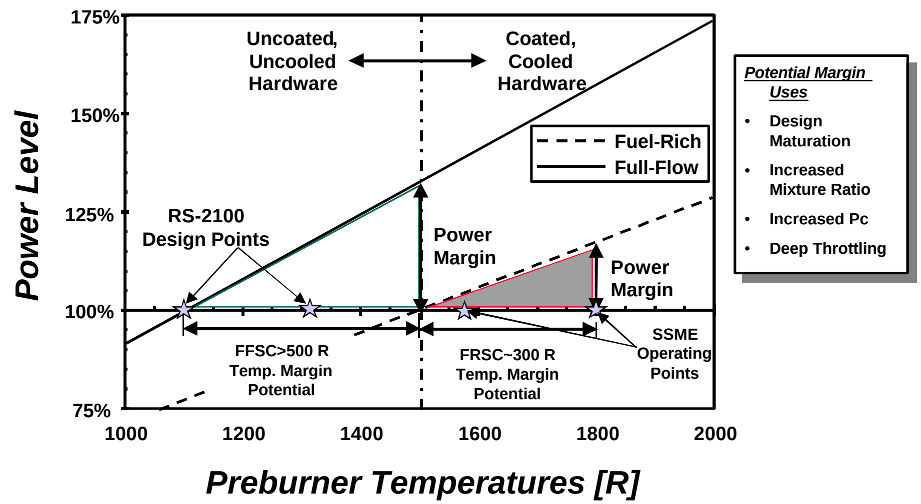
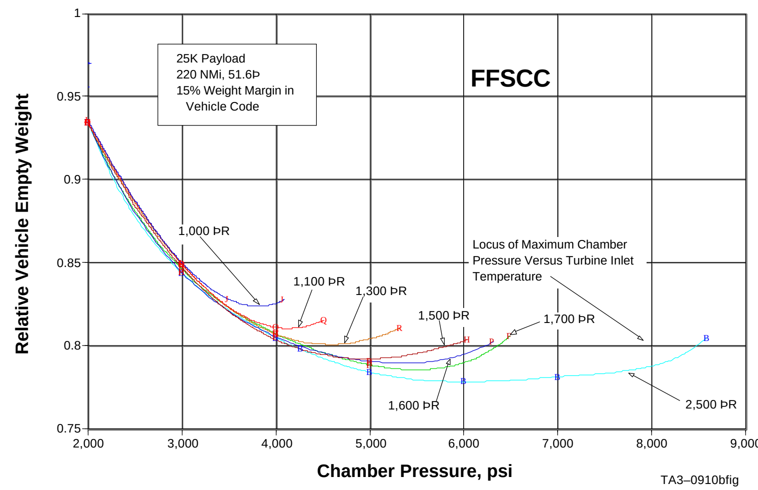
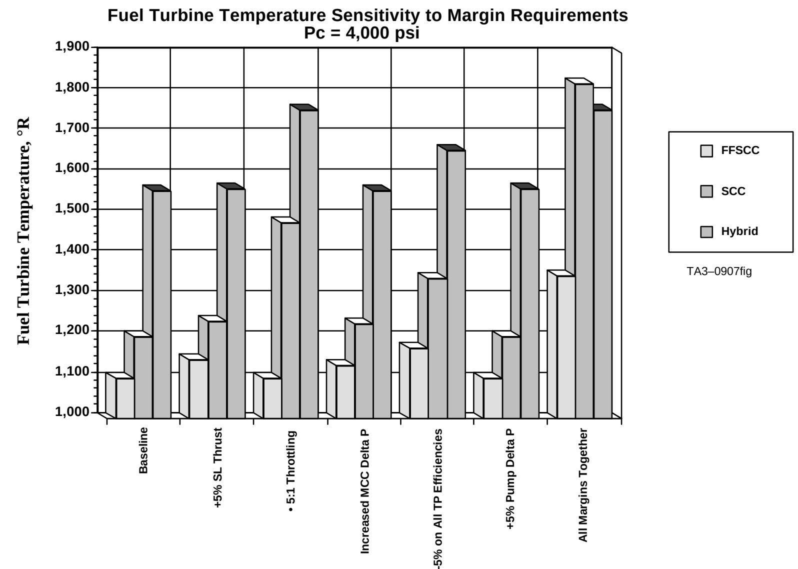


Potential Benefits
Long Life, High Thrust/Weight O_2/H_2 Rocket Engine

- FFSCC Produces the Highest Power Availability Possible
  - Fuel Rich Staged Combustion Cycle is Second Highest
- FFSCC Allows Very Low Turbine Temperatures Even in High P_c Engine
- Low Initial Turbine Temperatures Allows Wide Latitude to Solve Development Problems
- FFSCC is Very Robust in Margin Capabilities
  - Much More So Than Fuel Rich Staged Combustion Cycle
- Net Effect is Engine With Much More Benign Internal Environments Than SSME and With the Ability to Maintain Those Benign Environments Even With Development Problems



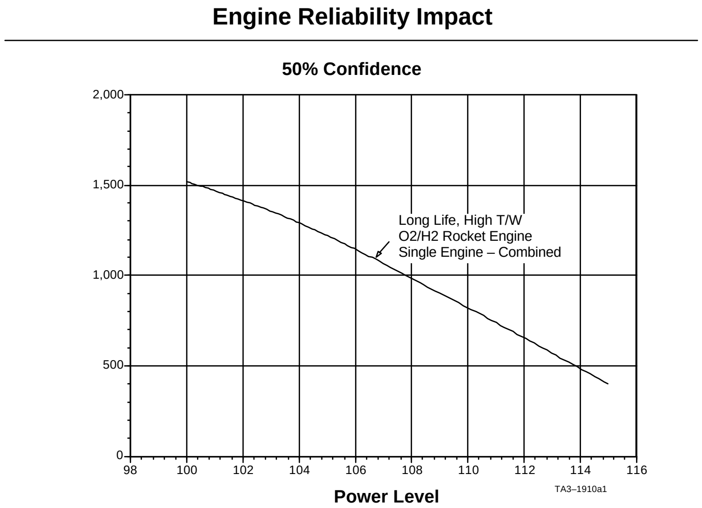


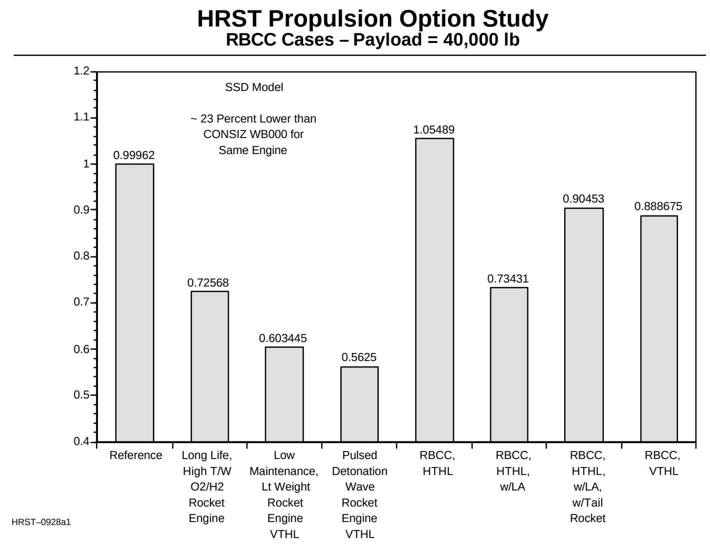
Potential Benefits
Long Life, High Thrust/Weight O_2/H_2 Rocket Engine

- The Benign Internal Environments of the FFSCC Produce an Engine With Long Life
  - In Excess of That Being Asked for in Gen 3 Designs

- An Engine of This I_{sp} and Thrust/Weight Produces a Very Competitive SSTO Design
  - Vehicle Dry Weights Equal to or Lower Than Many RBCC Designs
    - Using the Very Good T/W of 32.7 for the RBCCs
  - Gross Lift-Off Weights are About 50% higher than RBCC Cases

- **Allows Good SSTO Design Without the Risks Associated with Development of New Propulsion Technologies**





Current TRLs
Long Life, High Thrust/Weight O_2/H_2 Rocket Engine

OVERALL PROPULSION SYSTEM TECHNICAL MATURITY
<u>TRL = 5+ for basic component designs, 4 for nanophase Al</u>

<u>Maturity without use of new materials</u>

Gas/Gas Injection	TRL	5+
Ox Rich Preburner	TRL	5+
H_2 Rich Preburner	TRL	6-9
Laser Ignitors	TRL	5
Combustion Chamber	TRL	6-9
Nozzle	TRL	6-9
Nozzle Radiation Skirt	TRL	7
EMAs	TRL	6
Sector/Showerhead Valves	TRL	6
Low Part Count, Hydrostatic Bearing, No Interpropellant Seal Turbopumps (SLIC®)		
Up to 3 Stages	TRL	5
4 Stages H_2	TRL	4
Predictive, Adaptive, Integrated Condition/Health Monitoring		
Parts	TRL	6
Fully Integrated Concept	TRL	3-

<u>Maturity of new materials for rocket engine application</u>

Nanophase Al	TRL	4

Cost to Mature Technology

Long Life, High Thrust/Weight O_2/H_2 Rocket Engine

<table>
<tr><th>Years</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th></tr>
<tr><td>TRL 2: Basic principles observed and technology concept formulated</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>TRL 4: Component and/or breadboard validation in laboratory environment</td><td colspan="3">$10M</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>TRL 6: Prototype demonstration in a relevant environment</td><td></td><td></td><td></td><td colspan="3">$20M</td><td></td><td></td><td></td><td></td></tr>
<tr><td>TRL 8: System flight qualified through test and demonstration</td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="4">~ $650M</td></tr>
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