Development Activities on Airbreathing Combined Cycle Engines

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ART

(Advanced Reusable Transportation)
Recent Accomplishments

♦ Aerojet & Rocketdyne Flowpath Tested
  - Test Conducted From M 0 to Mach 8
  - Total Of 253 Test Conducted
  - Good Overall Performance

♦ Several Firsts In Testing
  - Dynamic Trajectory Simulation (AAR -> RAM and RAM-> SCRAM))
  - SCRAM Testing @ High Dynamic Pressure (M8 @ 1,200 Psf)
  - Rocketdyne A-5 engine has logged over 1 hour of accumulated test time
RBCC Focused Concept Flowpaths

Aerojet Flowpath

Rocketdyne Flowpath
## Accomplishments (cont’d)

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<th>Test 1</th>
<th>Test 2</th>
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<td>RAM</td>
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<td>Rocket-Only</td>
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<td>129</td>
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* Direct-Connect Tests
ART Future Plans

- Fabricate flight weight components
  - Rocketdyne combustor
  - Aerojet combustor
  - Aerojet ceramic ram/scram injectors
- Test selected components
- Document ART project

ART is scheduled to conclude in 2001
STAR

(Integrated System Test of an Airbreathing Rocket)
Combined Cycle Propulsion Testbed

*Take the next logical step in combined cycle propulsion development*

**Goal**
- Develop a flight-weight rocket based combined cycle engine system ground testbed capable of accelerating a self powered vehicle from Mach 0.8 to Mach 7

**Objective**
- Demonstrate RBCC engine system operation for air-augmented rocket, ramjet, and scramjet modes
- Provide testbed for evaluation of candidate innovative components
- Demonstrate flight weight engine system design and fabrication
- Evaluate engine system operational characteristics
- Flight engine system directly tracable to Ground test flight type hardware

**Mission Baseline**
- Lifting body configuration - ABLV4
- B-52 drop to Scramjet take over
- Descend and land
- Reusable system
- 25 flights

**Engine Systems**
- Provide for a propellant cooled power and thermal balanced flight type engine system
- Design for robust operations
- JP-7/Lox
Hydrocarbon Demonstrator Traceability

- The Hydrocarbon RBCC Engine Systems Demonstrator Provides Traceability to an Operational Launch Vehicle by ...
  
  • Developing a flight like, thermal & power balanced RBCC engine system
  
  • Demonstrating the operation of an RBCC engine system by testing from Mach 0 through Mach 7 in ground test
  
  • Performing vehicle design and propulsion system integration studies to show the applicability of RBCC to earth-to-orbit propulsion systems
On-Going Activities

♦ Industry Team is Key to Development - HYPAR
  • Preserve U.S. high speed propulsion industrial base
  • Rocketdyne - Management Lead
  • Pratt & Whitney - Technical Lead
  • Aerojet - Systems Integration Lead
  • MOU signed
  • FTC concurrence 8/4
  • Teaming agreement to be signed by 9/15
  • Program planning underway
  • Engine System Study final report week of 10/23

♦ Flowpath Selection Team
  • Team has been convening since June
    - Two representatives from each of the engine companies
    - One representative from Boeing Phantom Works
    - One representative from each participating NASA center (DFRC, GRC, LaRC, MSFC)
  • Data sharing initiated 7/24
  • Selection made 9/1 - Aerojet Strutjet Flowpath
Phased Approach

- Phase 1 - Systems Requirements Definition ~ 2 yr effort
  - Vehicle/Engine Integration, vehicle reqmts definition & flowdown to engine
  - Vehicle/Engine system trades and concept development
  - Early definition and evaluation of high risk components
  - Engine system requirements flowdown
    - Component specifications
    - Includes Cross-cutting components
  - Conduct SRR 5/’02

- Phase 2 - Engine System Design, Development & Test ~ 5 year effort
ISTAR Project Status

- **Industry Consortium Team Formed & Functioning**
  - Rocketdyne/Project Lead
  - Pratt & Whitney/Technical Lead
  - Aerojet/Systems Integration Lead
  - Boeing/Vehicle Conceptual Design Support (Not Part of Engine Consortium)

- **ISTAR Engine System & Vehicle System Closure Study Complete**
  - Final Review Held 10/31/00

- **ISTAR Project Planning Underway**
  - Preliminary WBS Defined
  - Task Schedule Identified
Industry & NASA Formed a Flowpath Selection Team to Down Select Between the Aerojet, Rocketdyne and Pratt & Whitney RBCC Engine Concepts

The Aerojet RBCC Flowpath and Engine System Concept was Selected as the Baseline
ISTAR Vehicle Subsystem Layout
'01 Plans

- Perform planning activity 11/00 - 4/01
- Get ATP 4/01
- Demonstrator vehicle activity led by LaRC
  - Feed requirements for engine system
## ISTAR Milestone Comparison

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- **Revised In-guideline**
- **Revised '03 Over-guideline** (same as Revised In-guideline for 1st 2 quarters)
- **Original In-guideline**
ISTAR - Technical Work Content Through SRR

♦ GFY’01
  - Part time Project Mgmt
  - Eng Sys & Flowpath SIPT (part time during jumpstart)
  - SSC Facility Reqmts
  - LaRC Inlet Entry
  - GRC Inlet Entry
  - LaRC SJ Cascade Inj. Charact.
  - GRC RJ Cascade Inj. Charact.
  - Team Performance Assessment
  - Team Tool Selection
  - Subscale HC Demo
  - Single Thruster Design
  - Fuels Characterization
  - Subscale Freejet Prep, Fab & Install
  - Veh/Eng Conceptual Design & Integration

♦ GFY’02
  - Full time Project Mgmt
  - Eng Sys & Flowpath SIPT
  - SRR
  - Single Thruster Design, Fab & Test
  - Strut Design (partial)
  - Fwd Duct Design (partial)
  - Aft Duct Design (partial)
  - Subscale Freejet Test