Development Activities on Airbreathing Combined Cycle Engines

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J. Craig McArthur
NASA Marshall Space Flight Center
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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<td>RAM</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 traceable 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
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
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 Conceptual Vehicle 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**
**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