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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<td>Sea-Level Static</td>
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<td>Air-Augmented Rocket</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
ISTAR

(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**
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
 ISTAR Baseline Flowpath Concept

- 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
RBCC Engine Current WBS

HYPAR Consortium
‘01 Plans

- Perform planning activity 11/00 - 4/01
- Get ATP 4/01
- Demonstrator vehicle activity led by LaRC
  - Feed requirements for engine system
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- **Diamond**: Revised In-guideline
- **Crossed Diamond**: Revised '03 Over-guideline (same as Revised In-guideline for 1st 2 quarters)
- **Triangle**: 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