SE/CP/IN/37

Turbine Based Combined / Combination Cycle / RTA Project Overview

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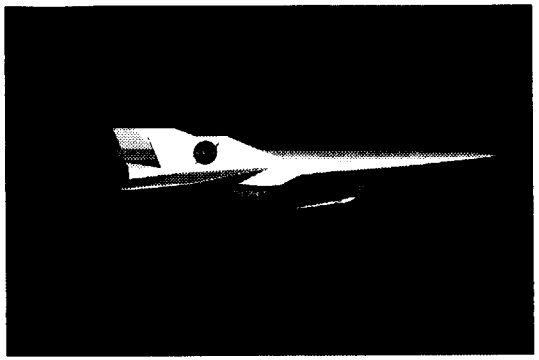
Space Transportation Technology Workshop



- Single Stage To Orbit (SSTO)
  - Turbine Accelerator Integrated with Dual Mode Scram Jet in Combined Flow Path
  - Over/under Configuration
  - Hyper-X type vehicle (Baseline)

- Technology Challenges
  - Turbine Accelerator
  - Shared Inlet
  - Dual Fuel (H/C & H2) in Single Vehicle
  - Transition Mode
  - Shared Mixer Ejector & Nozzle
  - Thermal Management
  - PAI

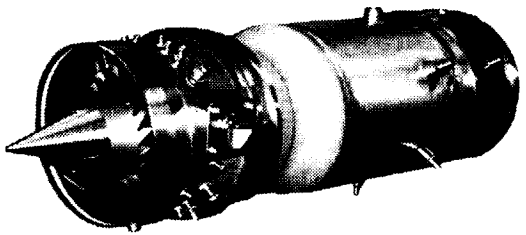
- Two Stage To Orbit (TSTO)
  - First Stage: Turbine Accelerator with Afterburner or Ram Jet
  - Second Stage: RBCC and/or Rockets

- Technology Challenges
  - Turbine Accelerator
  - Inlet Performance
  - Staging Separation
  - Thermal Management
  - PAI

Turbine Based Combined/Combination Cycle

Revolutionary Turbine Accelerator (RTA)

Thrust/Weight ~20 (in-line)
Mach 4-5 Capable
Long Life



♦ **Current State-of-the-Art**
- **J58 Mach 3+ capable engine**

♦ **Benefits of Technology**
- **Mach 4-5 turbine accelerator**
- **Simplifies ramjet/scramjet geometry (decreases weight)**
- **Improves system capacity & operability**
- **Improves safety, survivability, abort capability & launch flexibility**
- **Increases reliability & durability**

♦ **Technical Challenges**
- **High Mach compressor**
- **Thermal management**
- **Hot rotating components**
- **Advanced materials**
- **Propulsion/Airframe Integration**

♦ **Participants**
- **GRC (lead), LaRC, MSFC**
- **AF, NAVAIR**

Turbine Based Combined/Combination Cycle

Revolutionary Turbine Accelerator (RTA) Technologies

Small scale demo

~15" diameter
Limited life

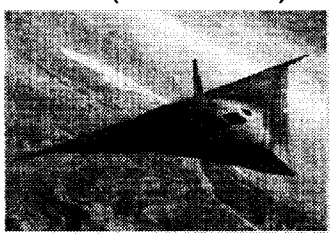
NAVY (IOC 2012)

High Speed Weapon (HSW) Missile
Mach 4+

Full scale demo

~58" diameter
Man-rated

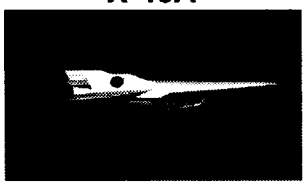
AF (IOC 2020+)



Future Strike Vehicle
Mach 2-4

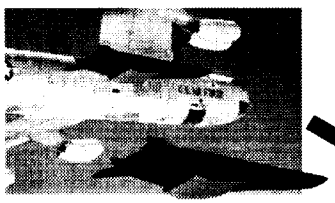
Dual Mode Scram Jet Technologies (Hyper-X)

X-43A



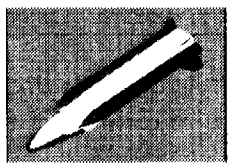
GH2

X-43B



TBCC H/C
Ram/Scram H/C

ARRMD



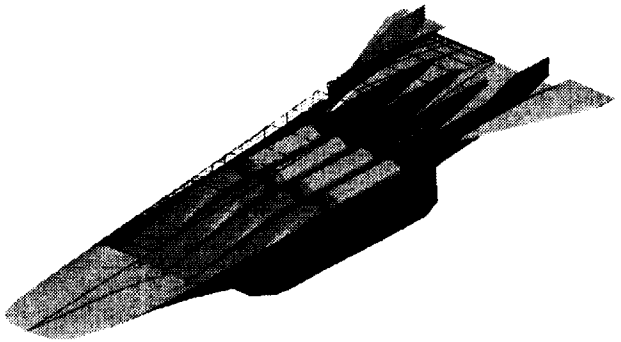
H/C

NASA & AF (IOC 2015+)

NASA 3rdGeneration RLV & AF SOV
Mach 4+ RTA for 1st stage
Mach 15+ for 2nd stage

Turbine Based Combined/Combination Cycle

SSTO (TBCC/RTA)



- **SSTO**
  - **Turbine Accelerator Integrated with Dual Mode Scram Jet in Combined Flow Path**
  - **Over/under Configuration**
  - **Hyper-X type vehicle (Baseline)**

Turbine Based Combined/Combination Cycle

TSTO (TBCC/RTA)

Vehicle System

- **First Stage:**
  Turbine Accelerator with Afterburner or Ram Jet

- **Second Stage:**
  AB RBCC and/or Rockets

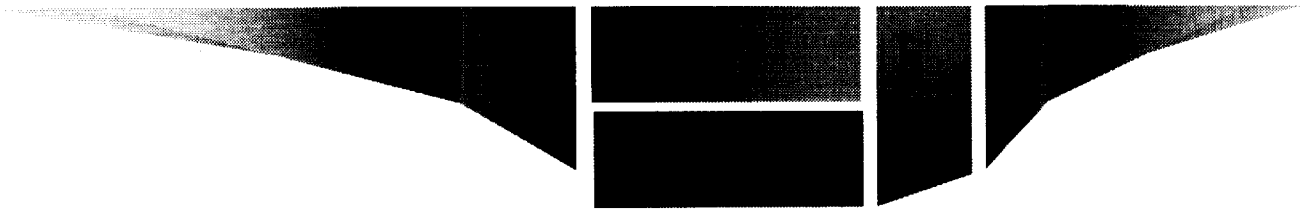
Turbine Based Combined/Combination Cycle

TBCC/RTA Technical Challenges

Inlet Design:
- Location (ahead, inside SJ inlet)
- Mode Transition
- Boundary layer control
- Performance
- Highly offset, subsonic diffuser
- Quality of flow
- Unstart susceptibility
- Separate inlets vs. single aperture
- Variable geometry (in or out doors)
- Weight/complexity

Turbine Accelerator:
- Protection from high temperatures for all configurations
- In flight restart

Nozzle:
- Exit location
- Design and performance
- Size & weight
- Mode transition interaction



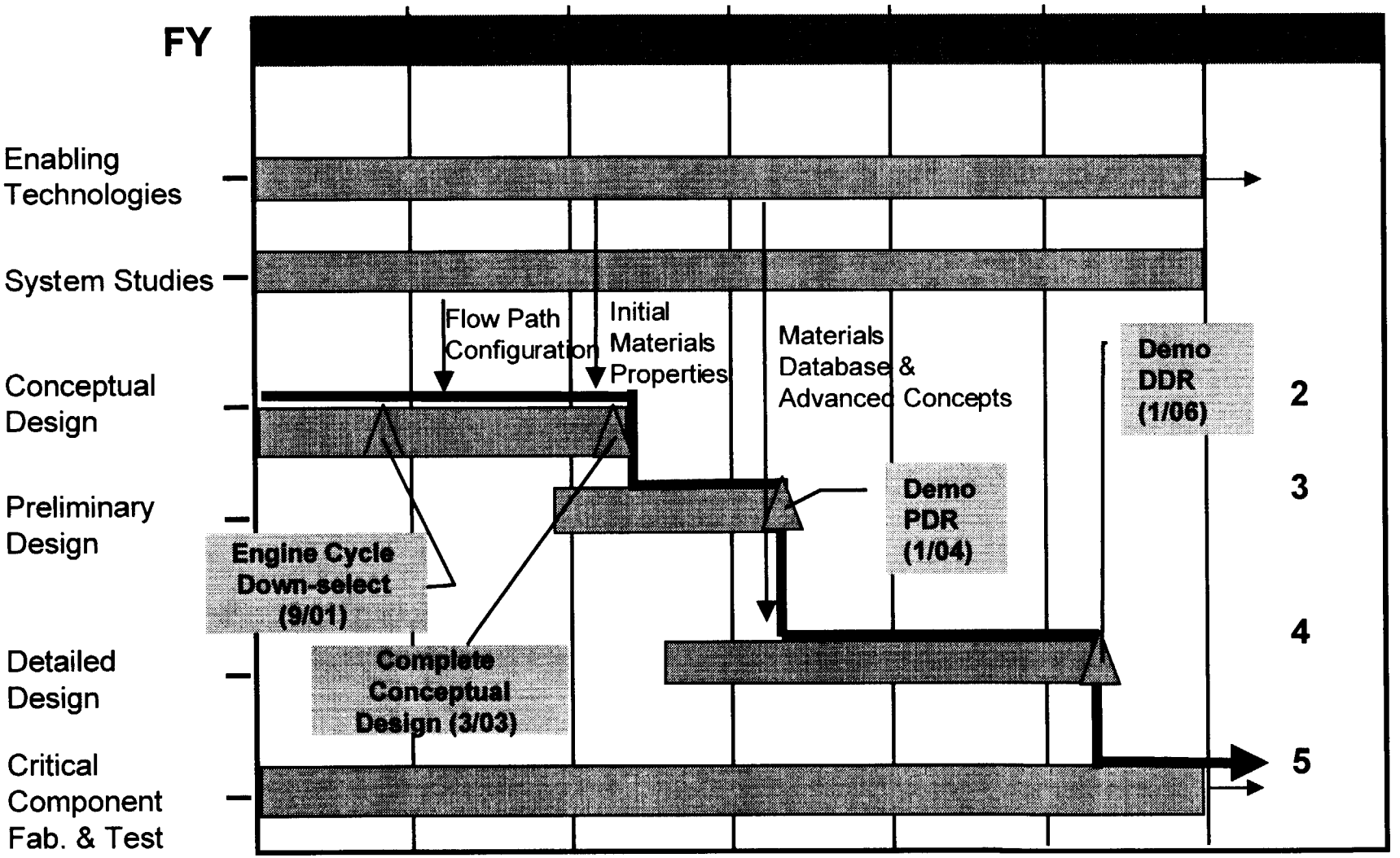
Additional Technical Challenges:
- Thermal management
- High temp seals
- Materials and Structures
- Integration
- Integrated flight controls
- Fuel system, cooling
- Vehicle design - CG, Pitching moment

RAM SCRAM:
High speed system flowpath design and performance

Ejector Region:
- Mixing performance and its impact on overall system performance
- Mixing enhancement
- Mode transition
- Thermal choke performance and locations control

Turbine Based Combined/Combination Cycle

TBCC/RTA Project Plan



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