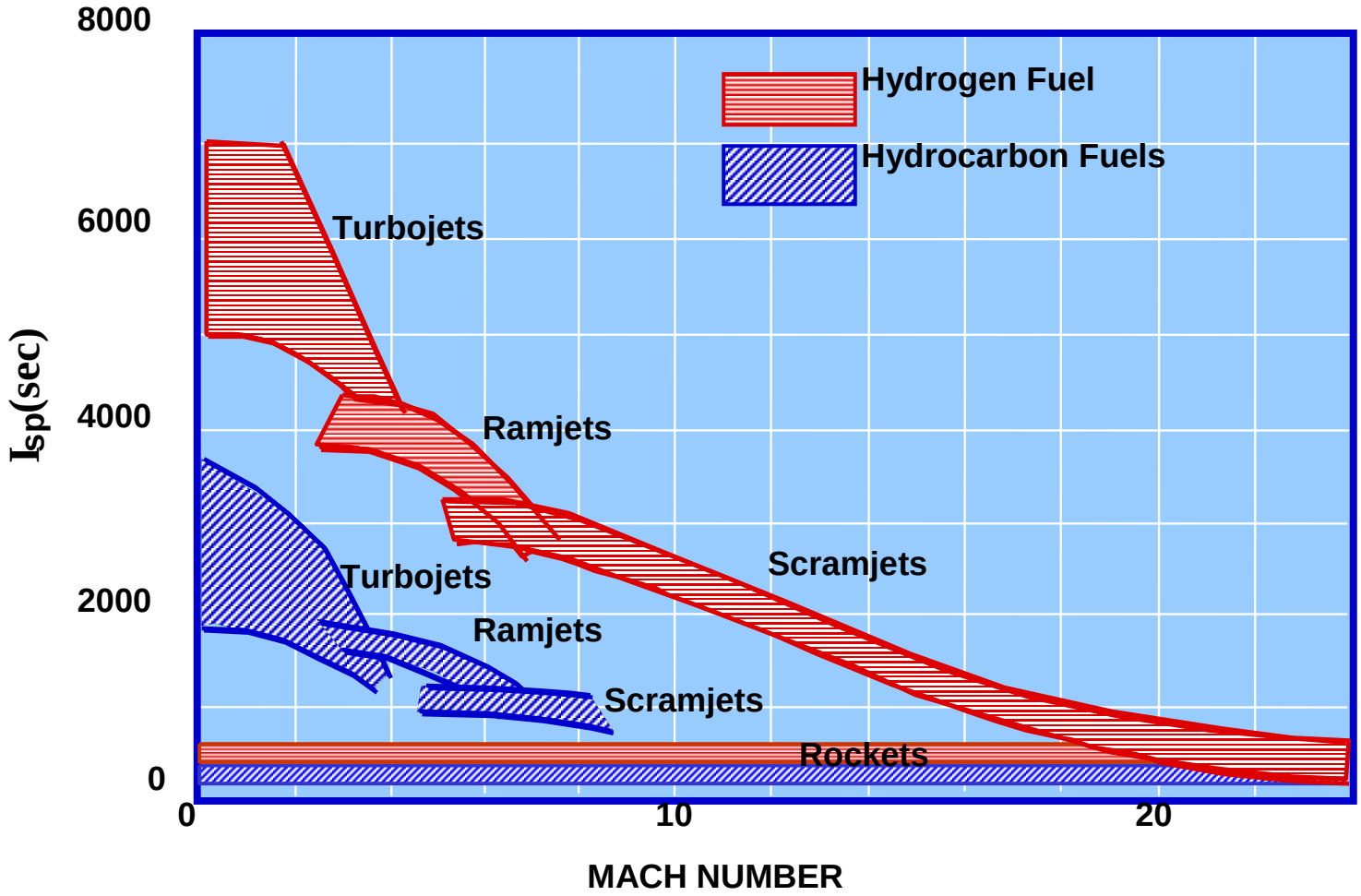
NASA'S ADVANCED SPACE TRANSPORTATION PROGRAM—RTA PROJECT SUMMARY

Paul Bartolotta and Nancy McNelis
National Aeronautics and Space Administration
Glenn Research Center
Cleveland, Ohio

Why Turbine Accelerators

Advanced Space Transportation Program



TBCC Interrelationships

Turbine Based System : Key to Enabling Tomorrow's Propulsion Systems

Access to Space

Space Shuttle

- $10,000/lb payload (Goal : $100/lb)
- Long Turn Around Time
- High Maintenance
- Re- usability <20 missions
- Limited Launch & Landing sites
- 8- 10 missions per year

Military

SR71

- Max. Mach = 3+
- Thrust/Weight = 4 (low)
- Maintenance High
- Elaborate Lubricants
- Durability Low

TBCC Features

Quick Turn Around Time (Airline like Operations)
Re- useable > 1000 missions
Versatile Usage & Launch and Landing sites
Low Maintenance
High Durability
1000's of Flights per Year
Mach >4
Thrust/Weight > 10
Cost: $ /lb Payload Low
Conventional Fuels & Lubricants

Future

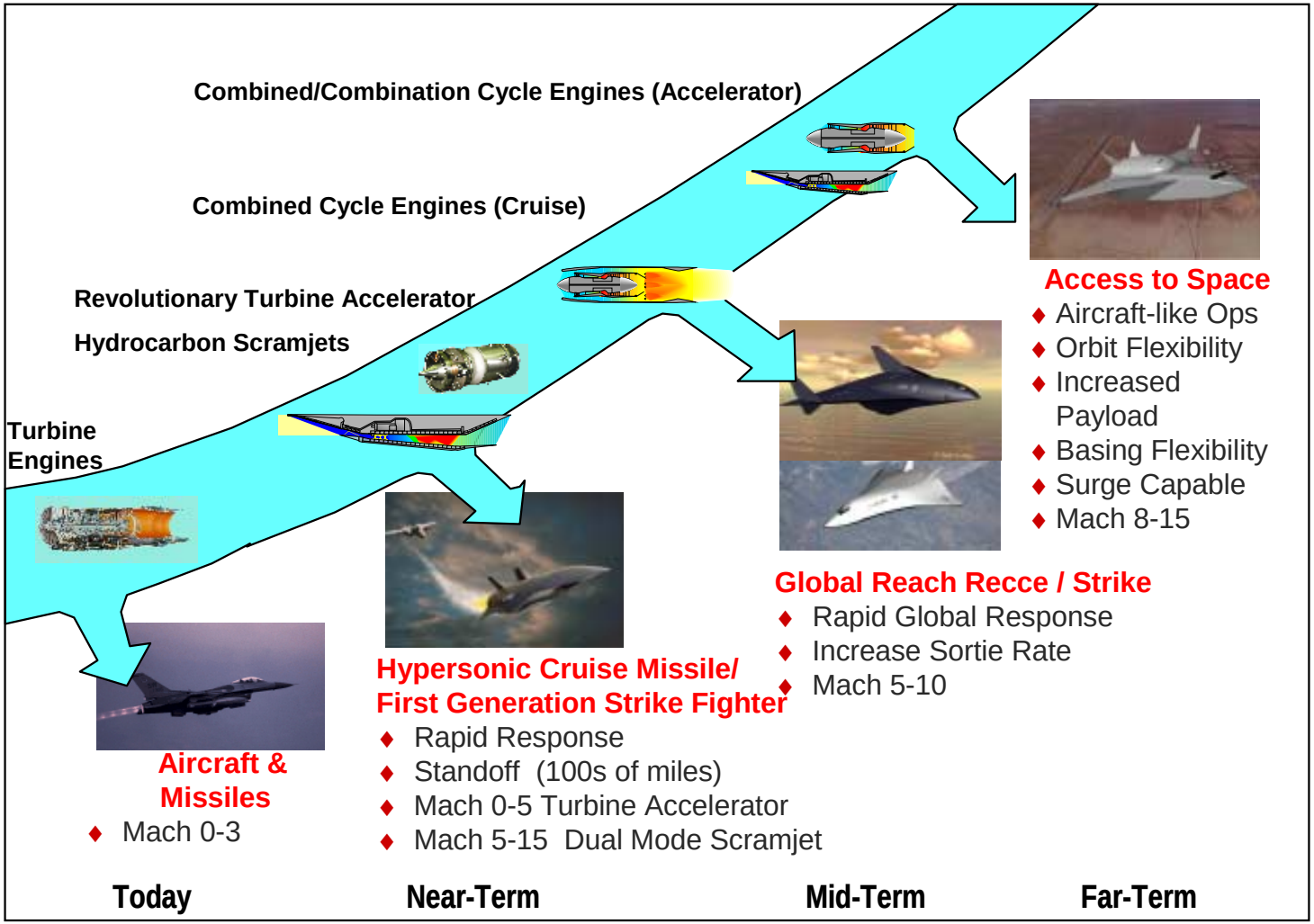
Air Travel

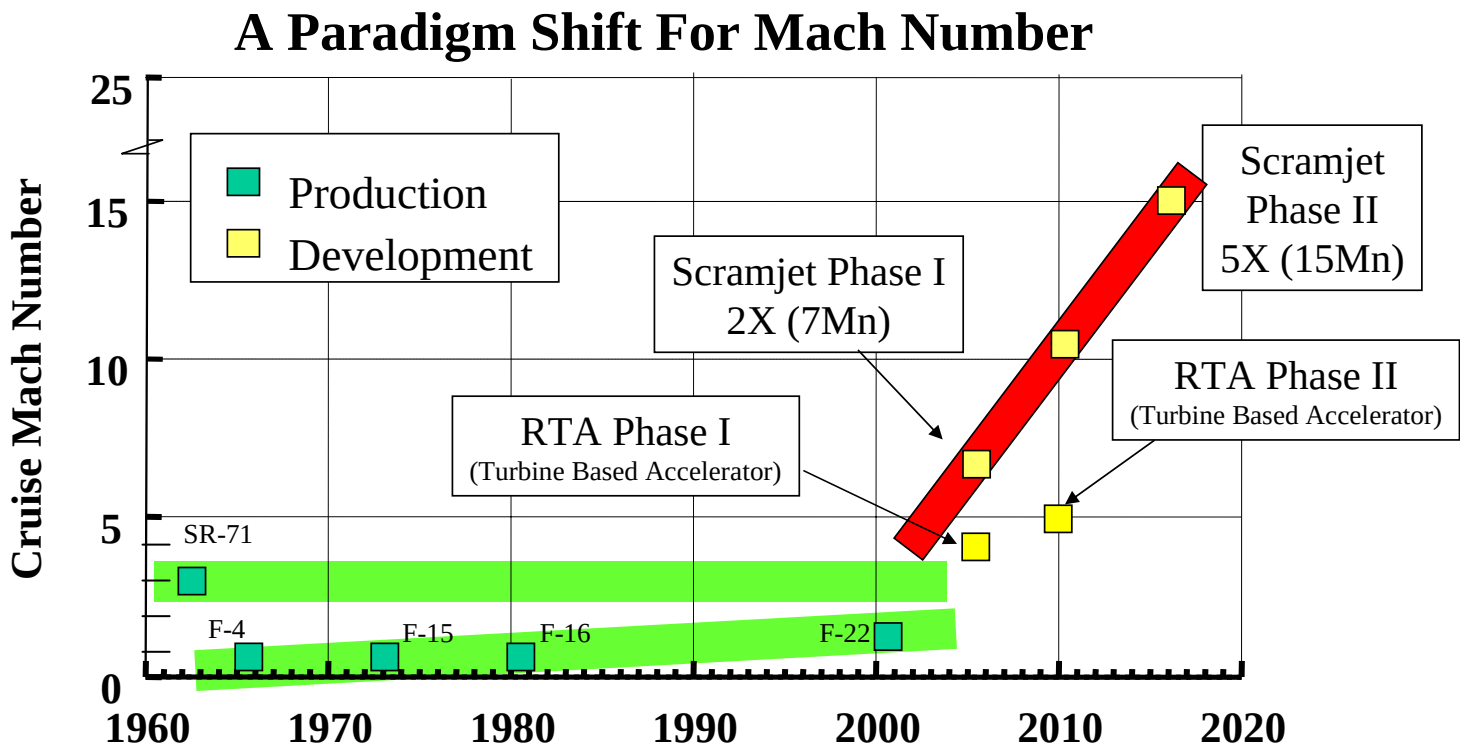
Concorde

- Max Mach = 2.
- $/Passenger: high (London to NY: $10,000)
- Sonic Boom

RTA Bridges the Gap Between Mach 3 & Mach 5

Advanced Space Transportation Program

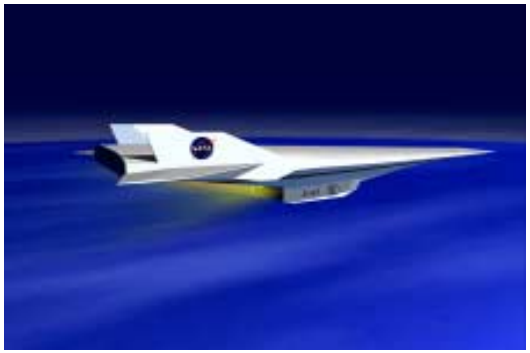




Airbreathing Propulsion Class, Baseline SR-71

Turbine Base Combination Cycle (TBCC)

Advanced Space Transportation Program



♦ **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** ***(T/W 15-20)***
- 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: AB RBCC and/or Rockets

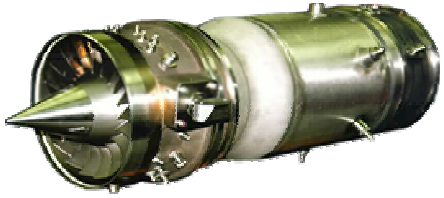
♦ **Technology Challenges** ***(T/W 10-15)***
- Turbine Accelerator
- Inlet Performance
- Staging Separation
- Thermal Management
- PAI

HYPERSONICS

Advanced Space Transportation Program

Revolutionary Turbine Accelerator (RTA)

Thrust/Weight 15-20
Mach 4-5 Capable
Long Life



♦ **Current State-of-the-Art**
- J58 Mach 3+ capable engine
- T/W =4

♦ **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

RTA Project Areas of Emphasis

Subscale Ground Based Testbed (GBT) Demonstrator (2001-2007)

- Develop & Demonstrate enabling turbine technologies required to meet ASTP objectives
- Demonstrate technologies on a proper scaled ground based testbed GBT
- Utilize GBT as a system to evaluate
  - Advanced Turbine Technologies
  - Windmilling at high Mach speeds
  - The "ilities" (I.e., Operability, Reliability, Durability)

Ground Based Testbed (GBT)

X43-B Flight Demonstration Propulsion Systems (2001-2003)

- Limited design effort for TBCC system in support of X43-B downselect
  - Conceptual design of TBCC propulsion system (RTA plus Dual Mode Scramjet) that could be available for CY 2009 first flight
  - Effort builds upon DoD IHPTET results
  - First flight in 2009 requires a technology freeze in 2005
  - If effort were continued & flown on X43-B, the PAI technology challenges will be addressed

Small-scale RTA

Dual Mode Scramjet (DMSJ)

X43-B flight demo vehicle

RTA GBT Goals & Objectives

- **Mission:** Develop & demonstrate a reusable turbine based propulsion system to meet future space access requirements (i.e., lower costs & increased safety)

- **Goal:** Develop and evaluate enabling technologies that significantly lower the cost for access-to-space and increase safety by providing performance margins which insure high reliability and durability.

- **Approach:**
  1. Develop & evaluate enabling technologies to improve performance above SOA.
  2. Incorporate and evaluate new advanced technologies (from ASTP as well as UEET, IHPTET, and VAATE) as they mature.
  3. Conduct investment studies for enabling technologies specific to RTA propulsion systems and use as key input to technology selection process
  4. Design and build a mid scale RTA ground based testbed (GBT)
  5. Utilize a combination of system studies & simulations to project propulsion system performance characteristics for both the demonstrator testbed and the full-scale vision propulsion system.

UEET: *Ultra Efficient Engine Technology program*
IHPTET: *Integrated High Pressure Turbine Engine Technology program*
VAATE: *Versatile Affordable Advanced Turbine Engine program*

HYPERSONICS

Summary

Advanced Space Transportation Program

- **Advantages of Turbine Based Combined Cycle**
  - *High ISP at M<5*
  - *Re-Useable w/ Versatile Launch & Landing*
  - *Quick Turn Around Time (Aircraft Like Operations)*
  - *Robust, Low Maintenance & Provides Performance Margins*
- **Critical Technologies Identified & Tech Development & Demo Plans Initiated**
  - *: Thermal Management*
  - *High Mach Capable Components*
  - *Materials and Structures*
  - *Operations / Systems*
- **RTA Project 2-Phase Approach**
  - *Ground Test Bed to Evaluate & Demonstrate Advanced Technologies, Operability and Performance, Reliability, and Durability – **FY 06***
  - *TBCC Flight Demo (X43B w/ over/under configuration) – **FY 09 (Unfunded)** to Demonstrate Integration & Transition of High Speed & Low Speed Propulsion Systems and Critical Propulsion / Airframe Integration Issues*

- **Success Dependent on Integrated / Coordinated Industry / Govt Teaming**
  (Airframer / Engine Contractor / System Analysis / Research / Testing / etc)