NASA Hypersonics Overview

November 2017

Outline

- Background
- Current Direction
- Capabilities
- Summary

Hypersonics is a Broad Mission Area

HYPERSONICS

- **Blunt Body Re-entry**
- **Unpowered Atmospheric Flight**
- **Powered / Sustained Atmospheric Flight**

Multiple NASA Missions require
Mastery of Hypersonic Flight

Guidance & Input

NASA Strategic Plan
"Advance aeronautics research for societal benefit"

National Aeronautics R&D Plan

2006 NRC Decadal Survey of Civil Aeronautics

2012 NRC Recapturing NASA's Aeronautics Flight Research Capabilities

Independent Studies
- Venture Capitalists
- Public/Private Consortium

Past NASA Programs/Projects
- ASTP, NGLT, AVTIP
- FAP

Feedback and Ideas:
- FY16 Industry Studies
- NASA internal

OGA / Coordinated Planning
- AFRL, DARPA, ONR, AFOSR
- JTOH, Hypersonic COI

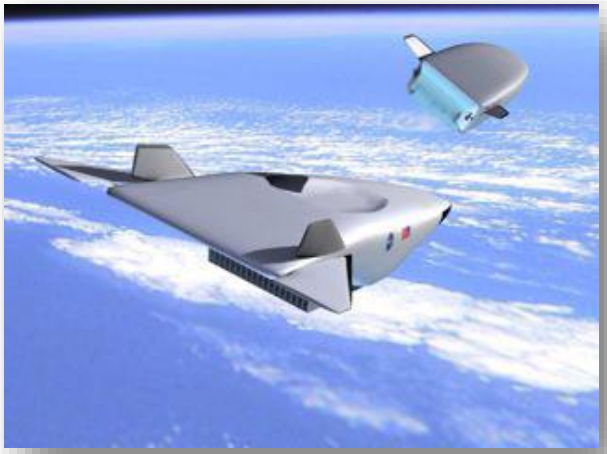
Reusable Hypersonics Research Themes and Technical Challenge Investments

Leveraging of Other NASA Projects
- Transformational Tools and Technologies Project (Combustion physics & controls, Alternative Fuels models, CMC materials, CFD methods)

Dependencies / Leveraging
- National Strategy
- DoD coordination: JTOH, Airplatforms High Speed/Hypersonics CoI

Enabling Routine Space Access

- **Hypersonic air-breathing technologies enable horizontal flight and aircraft-like operations**
  - Potential to seamlessly blend into national airspace
  - Aerodynamic flight enables abort modes across the flight profile
  - Conventional runway basing offers potential for more flexibility in operations including increased options for launch windows and increased orbit change / offset capability



- **Potential Applications**
  - Payload delivery, crew delivery, in-space servicing

Hypersonic air-breathing space access is still long term but offers significant benefits

National Approach

View of desired future capabilities – serves as an input for determining Community Outcomes & needed fundamental technology/capabilities.

Expendable

Tech Ready: 2020

Limited Reusable
(e.g., Air Launched)

Tech Ready: 2030

Reusable
(Runway Takeoff/Landing)

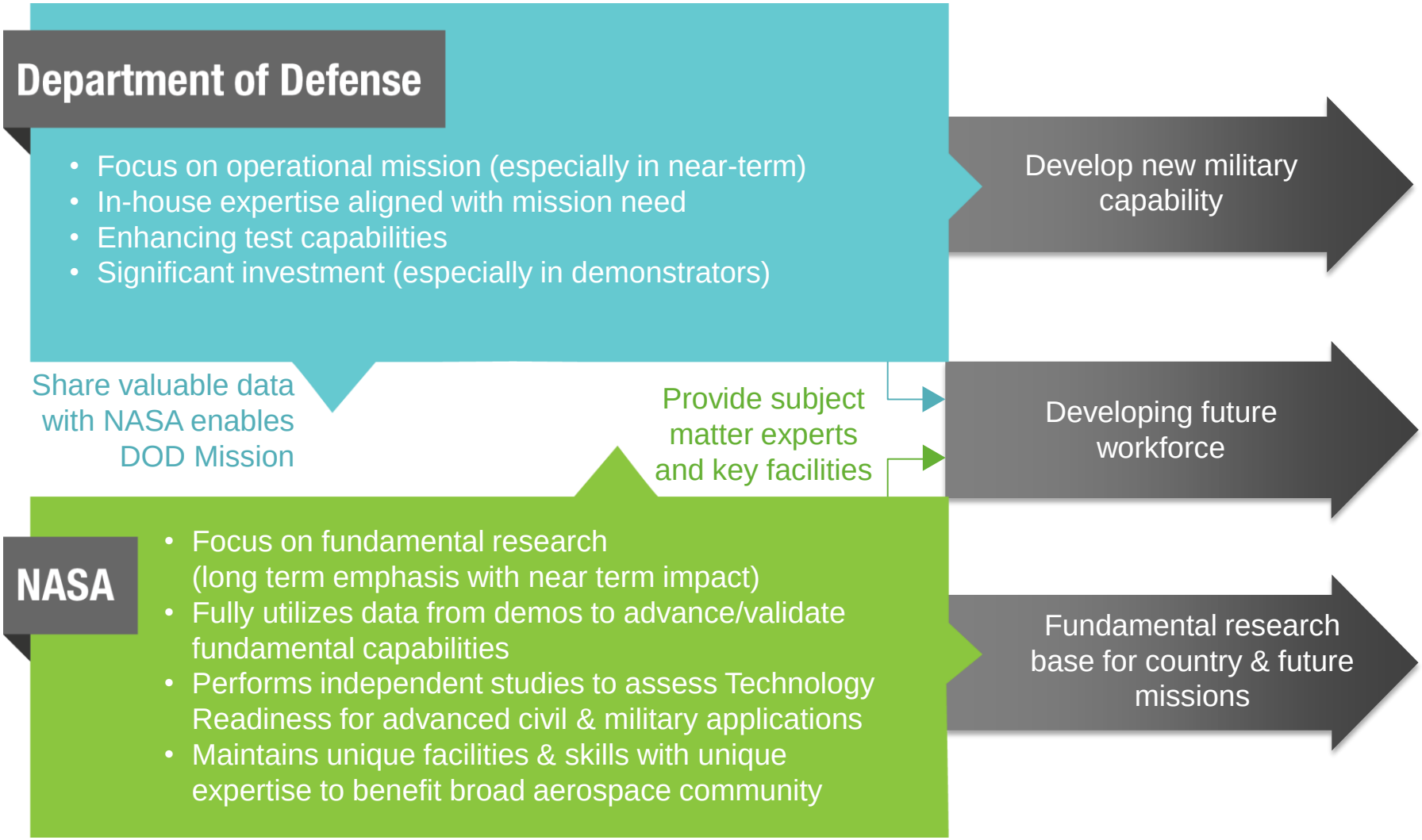
Tech Ready: 2040

Dual-use technologies: Potential civil applications (Point to Point Transport & Access to Space)

Weapons

Air Platforms

NASA Aeronautics/DoD: Leveraging hypersonic capabilities



Vision for the NASA Hypersonic Technology Project

Advance and Utilize Analytical Tools, Test Techniques, Fundamental Capabilities and Critical Technologies to Ensure US Supremacy in Hypersonics

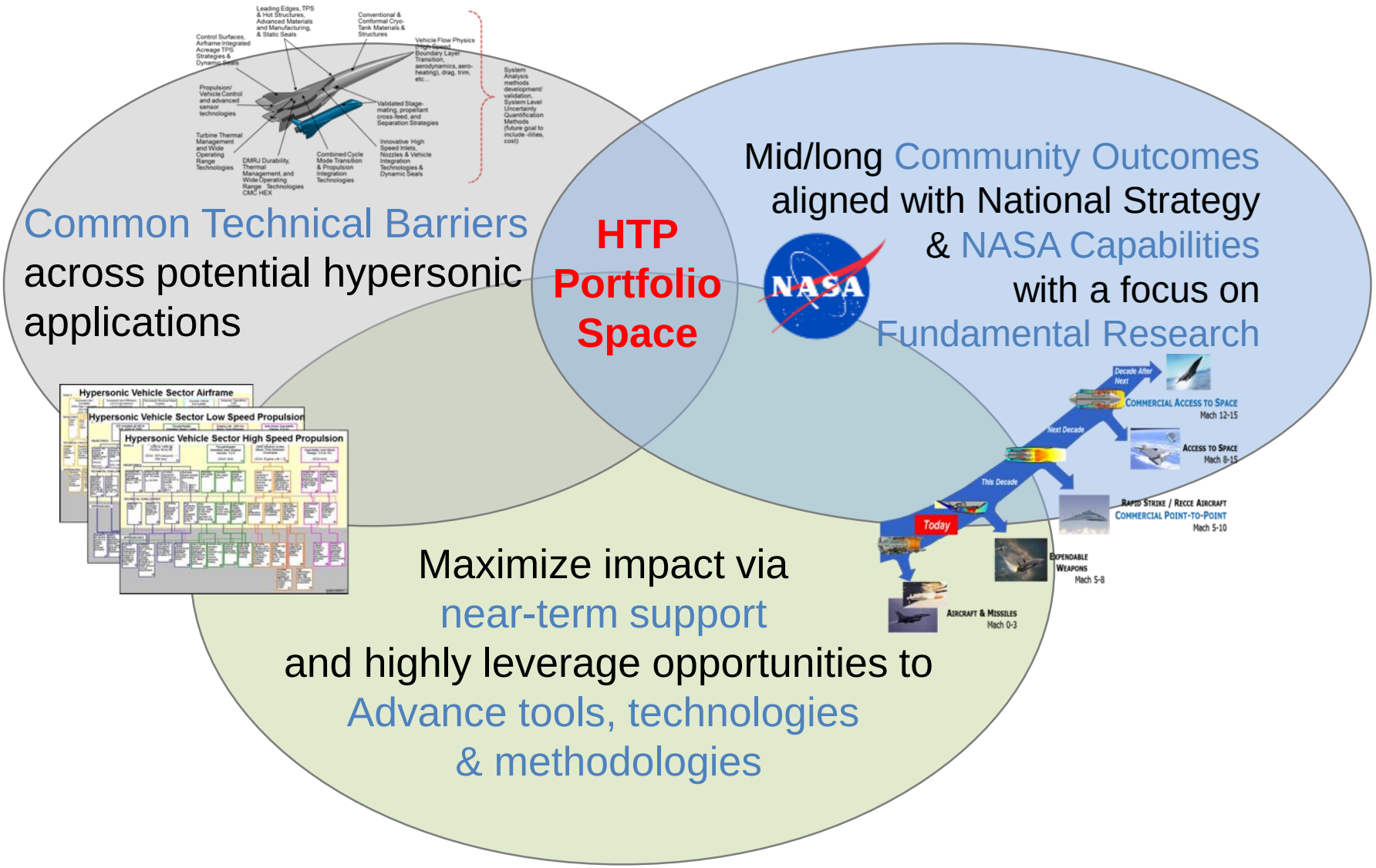
Vision

- Conduct fundamental research to enable a broad spectrum of hypersonic systems and missions by advancing the core capabilities and critical technologies underpinning the mastery of hypersonic flight and bringing them to bare on National Programs

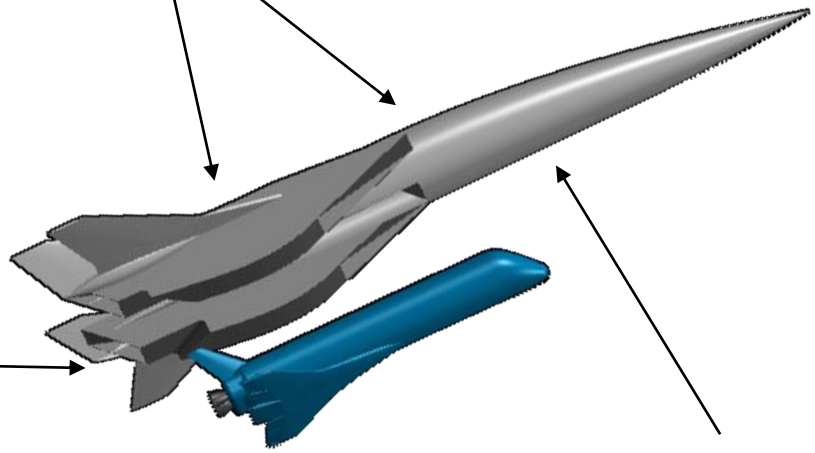
Scope

- Fundamental research spanning technology readiness and system complexity levels
- Critical technologies enabling re-usable hypersonic systems
- System-level research, design, analysis, validation
- Engage, invigorate and train the next generation of engineers

HTP Portfolio Development



Common Barriers to Full Spectrum of Reusable Hypersonic Applications



High Temperature, Durable Materials

Vehicle Technologies

System Level Design, Analysis, Validation

Propulsion Technologies

Thermal Protection Systems

NASA Focus Area

NASA investment

Minimum NASA Investment

Advances are being made in key areas laying the ground for a flight demonstrator that will be eventually needed to prove the concept.

NASA Research Leverages and Supports National Activities

Feedback knowledge

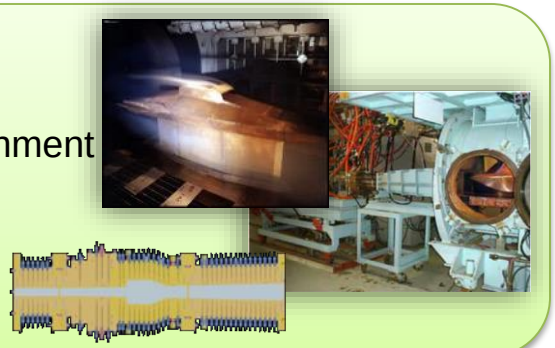
Flight Test

- Most similar to operational environment
- Least available, but most valuable data

VALIDATION DATA

Ground Test

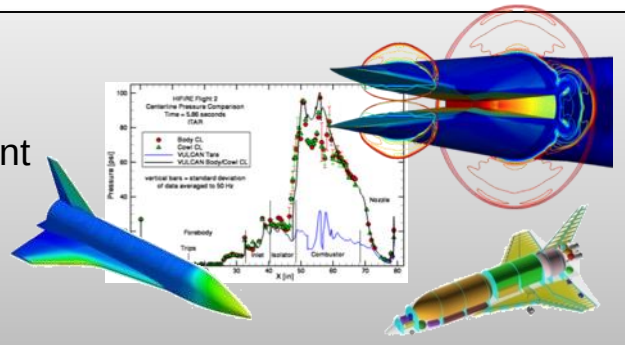
- Not a perfect match to operational environment
  - Vitiation
  - Test duration
  - Test conditions
  - Scale



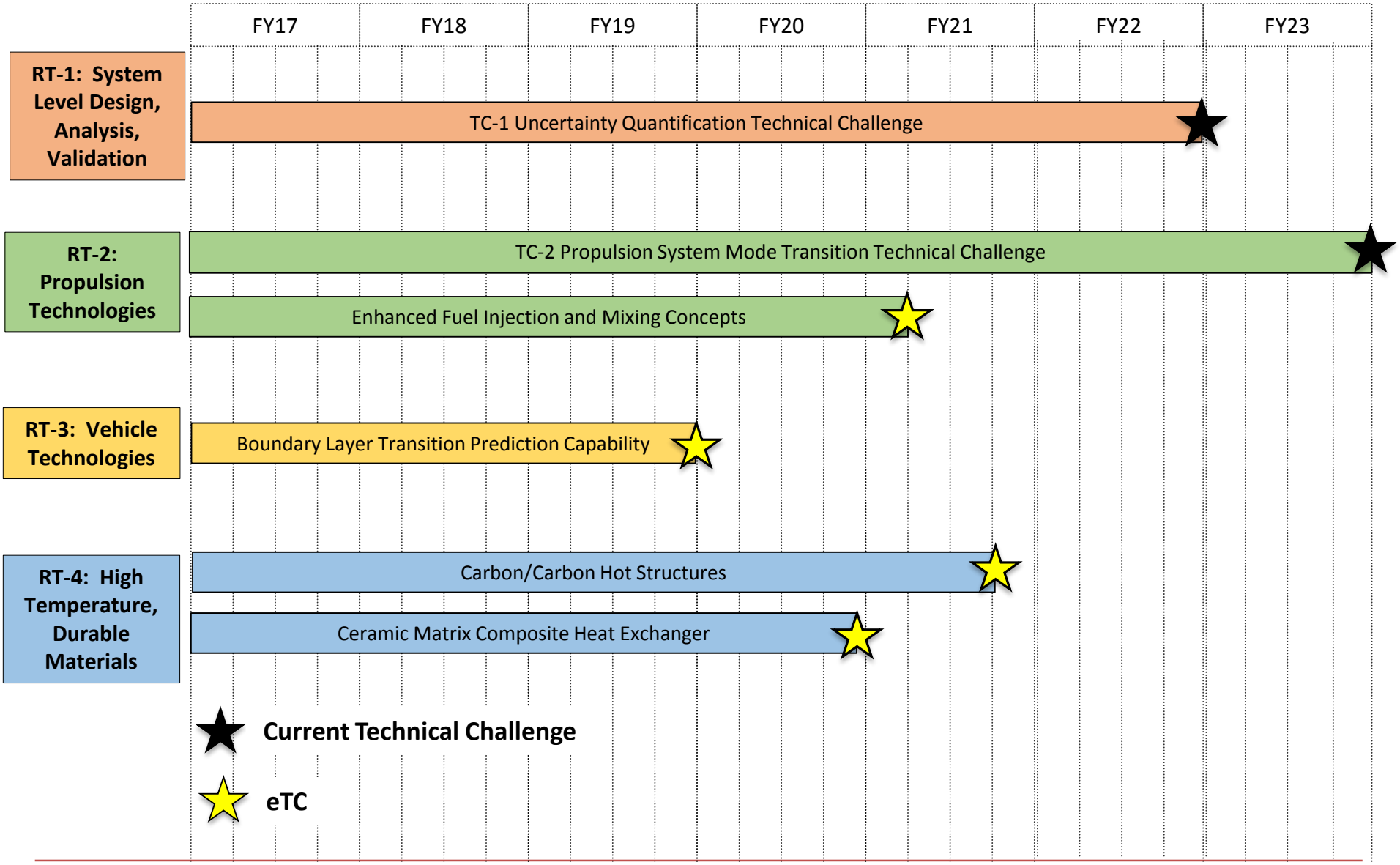
DATA

Modeling & Simulation Tools / Fundamental Research

- Not a perfect match to operational environment
  - Static geometry
  - Boundary conditions
  - Match improves with test data



HTP Technical Challenges Execution Window



Example of Combined Cycle Mode Transition Testing

Tech Benefit: *Combined cycle (CC) propulsion systems* would greatly increase the flexibility and utility of the next generation high-speed reusable vehicles via combining fuel efficiencies of turbine engines with the thrust density and high speed operations of scramjets.

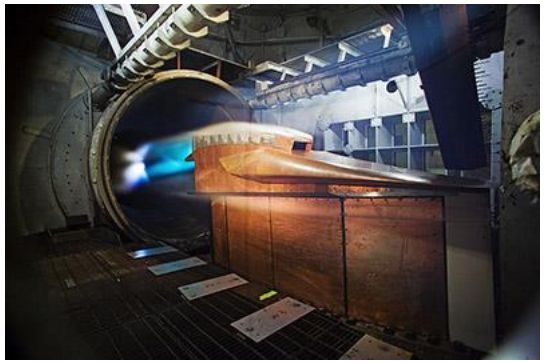
Objective: Demonstrate autonomous control and establish performance/operability assessment methodologies for future reusable hypersonic propulsion systems that use turbine engines at slow speeds and transition to scramjets for high-speed operations.

Impact

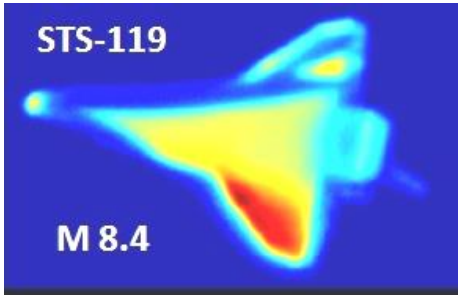
- Provides Hypersonics community data on mode transition technologies, identifies unknown-unknowns, and represents the first demonstration of autonomous mode transition between two completely different types of airbreathing engines
- Delivers the methodology and control theory for autonomous mode transition

Combined Cycle Engine Testing in GRC 10x10

NASA Core Hypersonic Competencies



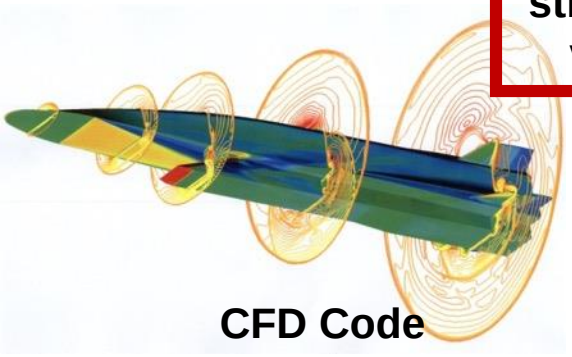
Hypersonic Airbreathing Propulsion



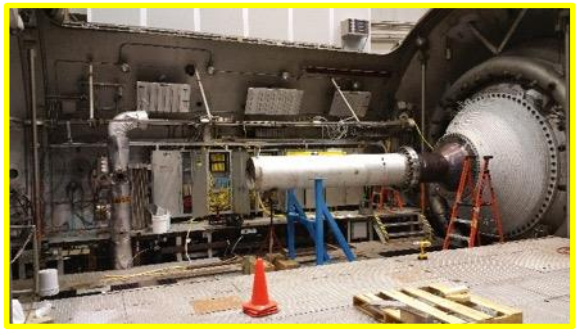
Aerosciences

Vehicle Level Conceptual Design & Systems Analysis

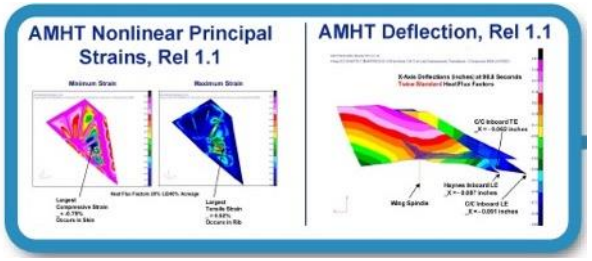
NASA has the knowledge to develop and apply our world class combination of computational expertise, experimental facilities and flight experience in propulsion, aerothermodynamics, materials, thermal structures, guidance & control and conceptual vehicle design to deliver mission success.



CFD Code Development / Application



Ground Testing & Diagnostics



Structures & Materials

NASA Hypersonic Propulsion Test Facilities

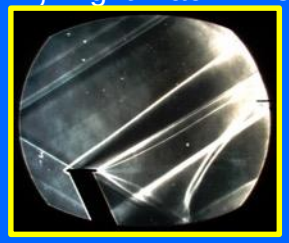
8-Ft. High Temperature Tunnel (8-Ft. HTT)
Flight Mach Enthalpy: 3 - 7

10x10
Flight Mach: 2.0 - 3.6

Arc-Heated Scramjet Test Facility (AHSTF)
Flight Mach Enthalpy: 4.7- 8

Propulsion Systems Lab (PSL)
Flight Mach Enthalpy: 4.7- 8

1x1, Flight Mach: 1.5 - 6



Unitary Plan Wind Tunnel (UPWT)
Flight Mach: 1.5 - 4.6

Direct-Connect Supersonic Combustion Test Facility (DCSCTF)
Flight Mach Enthalpy: 4.5 - 7

Why NASA?

- NASA has developed the skilled workforce and several key facilities needed to help the Nation maintain pre-eminence in hypersonic technology development.
- NASA's hypersonics capability, coupled with a healthy research program, enables future military, civil and commercial missions and helps sustain U.S. preeminence in this strategic technology.
- NASA is in an excellent position to re-invigorate and engage future workforce
- The cost for the DoD to replicate and develop similar capabilities will require additional resources and delay current R&D efforts.

Summary

- NASA has a long history of working closely with the DoD to develop a National Hypersonic Capability.
- While the near-term application for hypersonics is military related, NASA supports the National Strategy in the near term with unique expertise and facilities.
- At the same time NASA can leverage the DoD investments in flight projects to greatly enhance fundamental research
- The new Hypersonics Technology project is well coordinated with National Efforts and is advancing research in key technologies