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

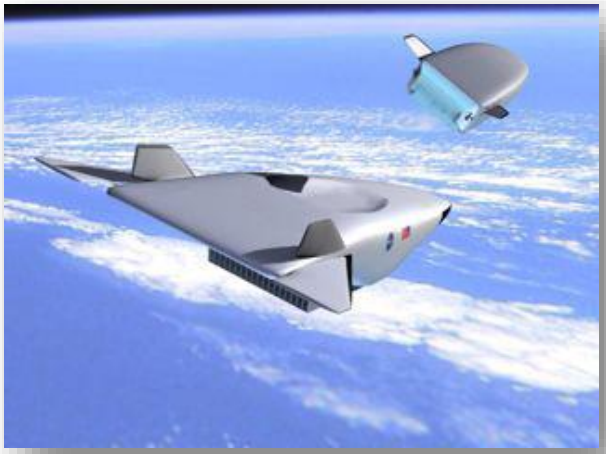
Reusable Hypersonics Research Themes and Technical Challenge Investments

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.

Reusable
(Runway Takeoff/Landing)

Tech Ready: 2040

Limited Reusable
(e.g., Air Launched)

Tech Ready: 2030

Expendable

Tech Ready: 2020

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

Weapons

Air Platforms

NASA Aeronautics/DoD: Leveraging hypersonic capabilities

Department of Defense

- Focus on operational mission (especially in near-term)
- In-house expertise aligned with mission need
- Enhancing test capabilities
- Significant investment (especially in demonstrators)

Develop new military capability

Share valuable data with NASA enables DOD Mission

Provide subject matter experts and key facilities

Developing future workforce

NASA

- Focus on fundamental research (long term emphasis with near term impact)
- Fully utilizes data from demos to advance/validate fundamental capabilities
- Performs independent studies to assess Technology Readiness for advanced civil & military applications
- Maintains unique facilities & skills with unique expertise to benefit broad aerospace community

Fundamental research base for country & future missions

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

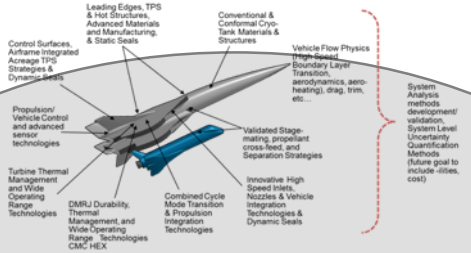
Vision

- 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

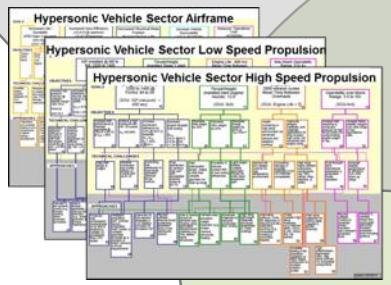
HTP Portfolio Development



Common Technical Barriers
across potential hypersonic applications

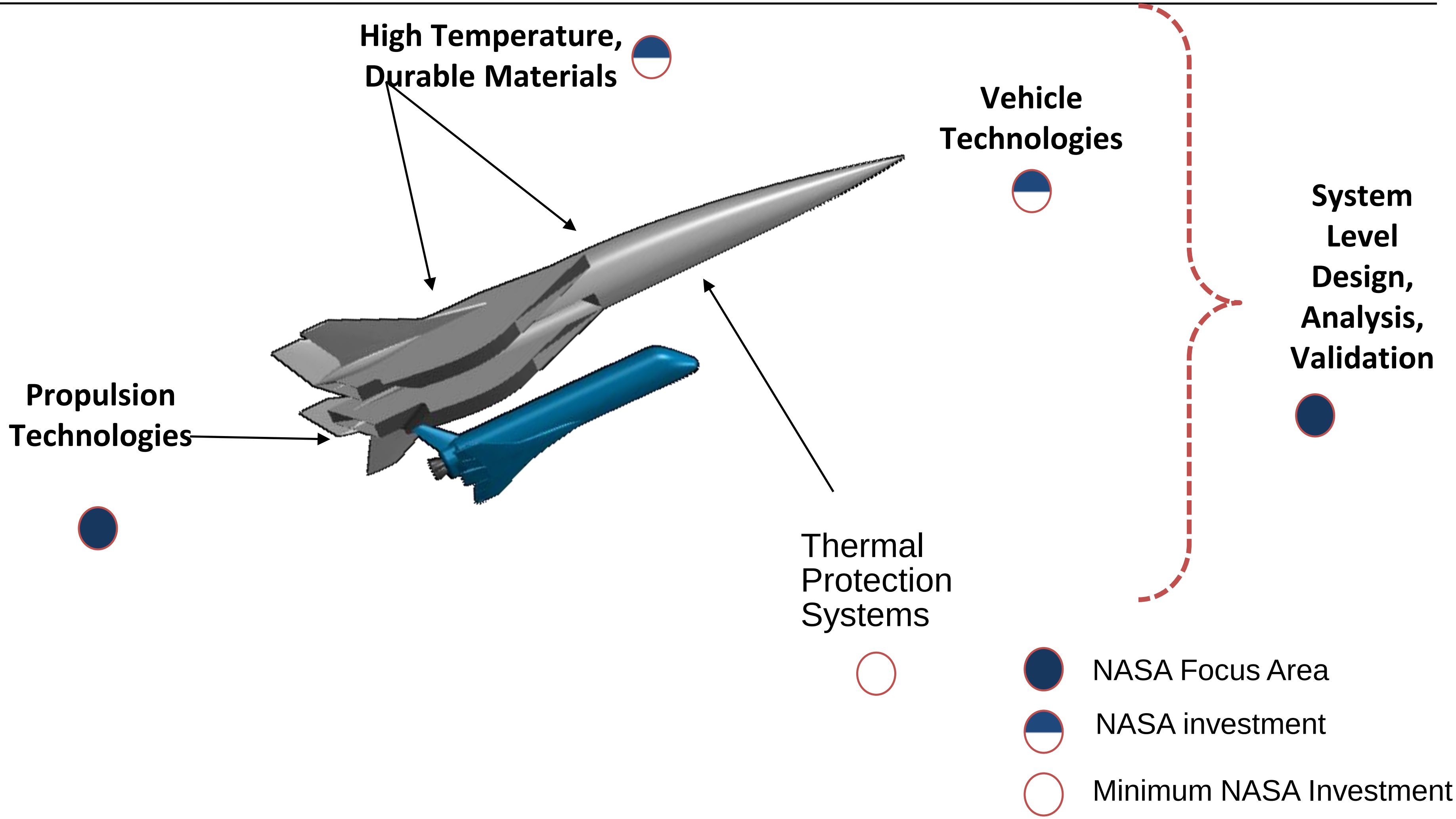
HTP Portfolio Space

Mid/long Community Outcomes
aligned with National Strategy
& NASA Capabilities
with a focus on
Fundamental Research



Maximize impact via
near-term support
and highly leverage opportunities to
Advance tools, technologies
& methodologies

Common Barriers to Full Spectrum of Reusable Hypersonic Applications



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

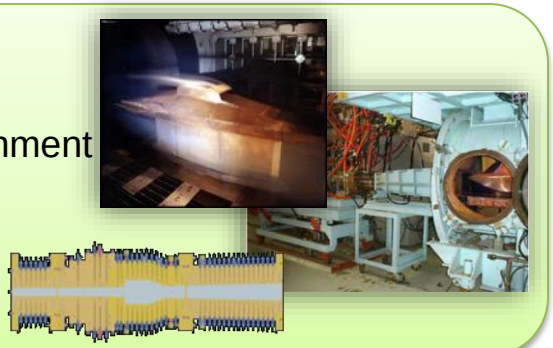
Flight Test

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

VALIDATION DATA

Ground Test

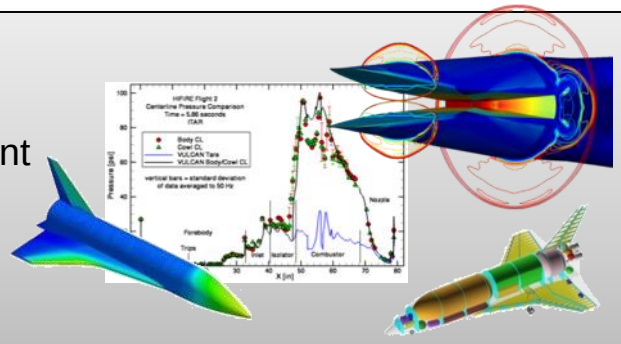
- Not a perfect match to operational environment
  - Vitiation
  - Test duration
  - Test conditions
  - Scale



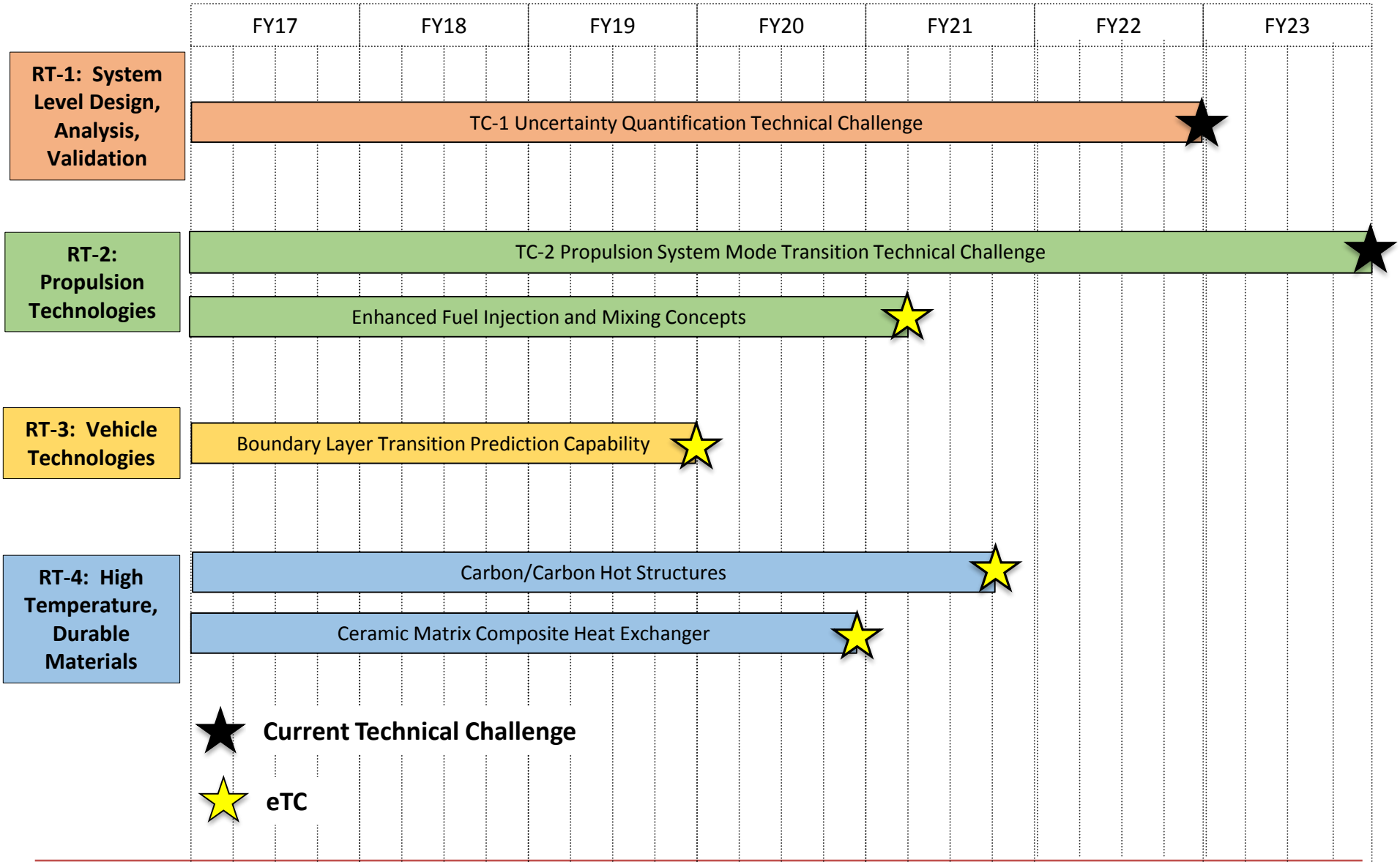
DATA

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.

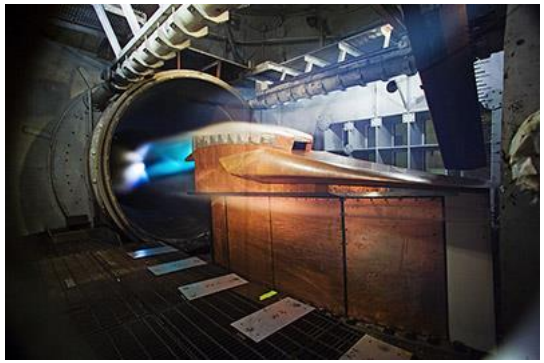
Objective: Demonstrate autonomous control and establish performance/operability assessment methodologies for future reusable hypersonic propulsion systems that use turbine engines at slow speeds and transition to scramjets for high-speed operations.

Impact

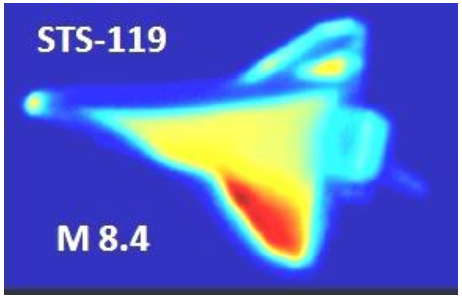
- Provides Hypersonics community data on mode transition technologies, identifies unknown-unknowns, and represents the first demonstration of autonomous mode transition between two completely different types of airbreathing engines
- Delivers the methodology and control theory for autonomous mode transition

Combined Cycle Engine Testing in GRC 10x10

NASA Core Hypersonic Competencies



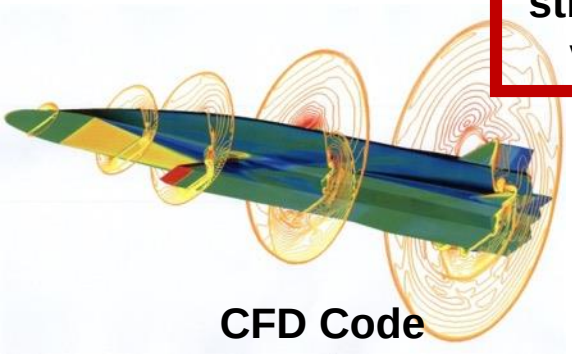
Hypersonic Airbreathing Propulsion



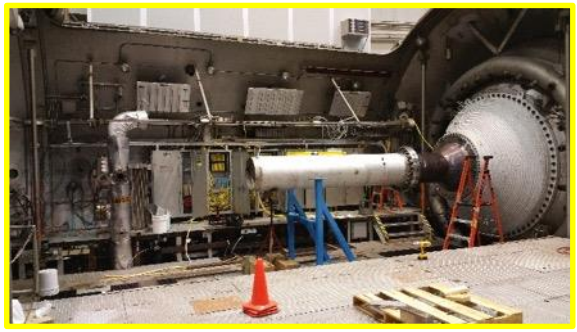
Aerosciences

Vehicle Level Conceptual Design & Systems Analysis

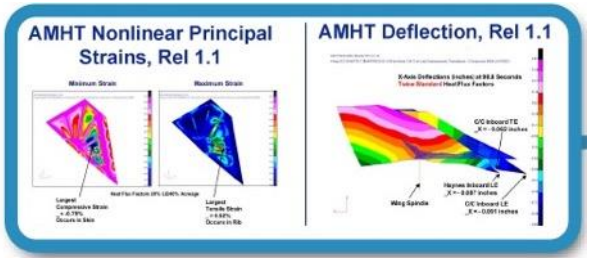
NASA has the knowledge to develop and apply our world class combination of computational expertise, experimental facilities and flight experience in propulsion, aerothermodynamics, materials, thermal structures, guidance & control and conceptual vehicle design to deliver mission success.



CFD Code Development / Application



Ground Testing & Diagnostics



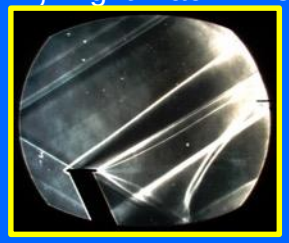
Structures & Materials

NASA Hypersonic Propulsion Test Facilities

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

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

1x1, Flight Mach: 1.5 - 6



10x10
Flight Mach: 2.0 - 3.6

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

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

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