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

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)

Share valuable data with NASA enables DOD Mission

Provide subject matter experts and key facilities

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

Develop new military capability

Developing future workforce

Fundamental research base for country & future missions
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
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

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

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

**Modeling & Simulation Tools / Fundamental Research**
- Not a perfect match to operational environment
  - Static geometry
  - Boundary conditions
  - Match improves with test data

VALIDATION DATA

DATA

Feedback knowledge
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**RT-1: System Level Design, Analysis, Validation**

**TC-1 Uncertainty Quantification Technical Challenge**

**RT-2: Propulsion Technologies**

**TC-2 Propulsion System Mode Transition Technical Challenge**

**Enhanced Fuel Injection and Mixing Concepts**

**RT-3: Vehicle Technologies**

**Boundary Layer Transition Prediction Capability**

**RT-4: High Temperature, Durable Materials**

**Carbon/Carbon Hot Structures**

**Ceramic Matrix Composite Heat Exchanger**

**Current Technical Challenge**

**eTC**
**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-ununknowns, 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
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.
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

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

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

- **1x1**
  - Flight Mach: 1.5 - 6
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.