



Update on United States Hypersonics Activities

David E. Glass

NASA Langley Research Center, Hampton, VA 23681

The 3rd International Conference on High-Speed Vehicle Science and Technology (HiSST)

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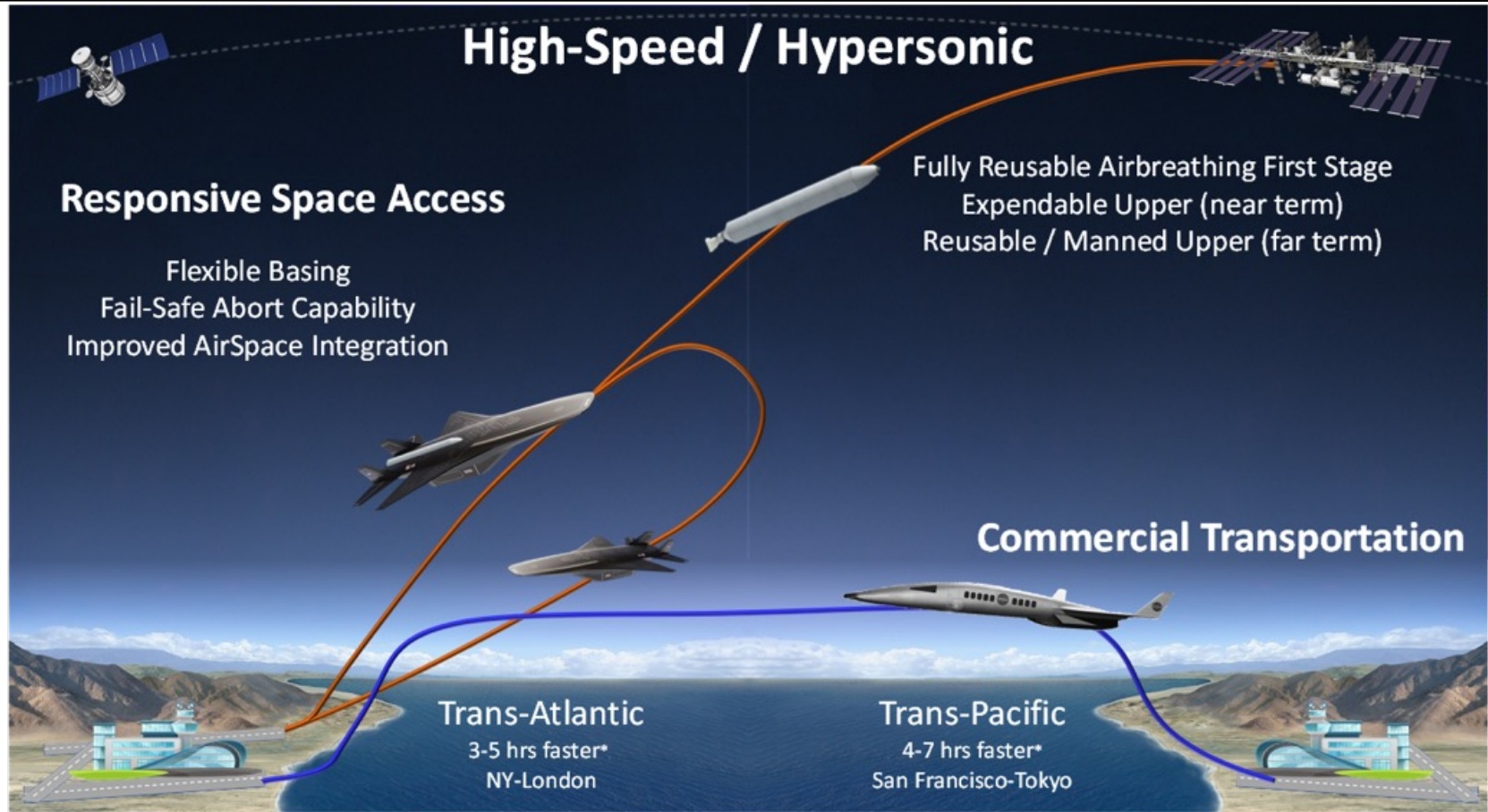
Outline



- NASA
- Air Force Research Lab (AFRL) ceramics research
- JHTO (Joint Hypersonic Transition Office)
- BOLT (Boundary Layer Transition) flight experiment
- Stratolaunch Talon A
- Sierra Space Dream Chaser
- US Air Force collaborations

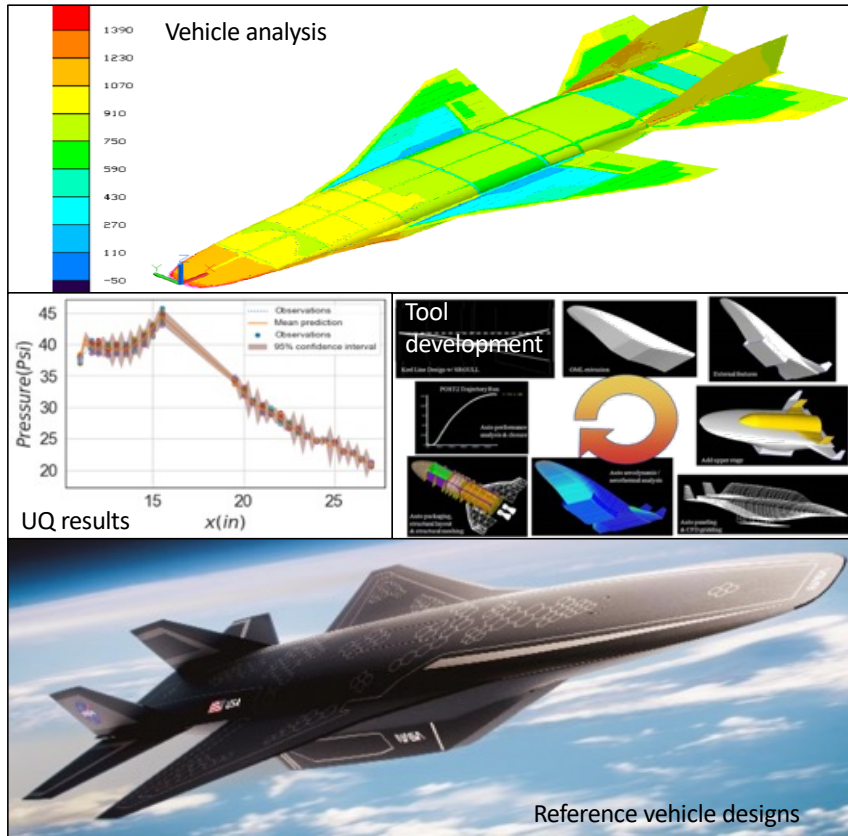


Enable Routine, Reusable, Airbreathing Hypersonic Flight





RT-1: System Level Design, Analysis, and Validation



Research Topic 1.1 (RT-1.1): Multidisciplinary Design/Optimization and Uncertainty Quantification (MDAO & UQ)

RT-1.2: Fluid-Thermal-Structural Interaction (FTSI)

RT-1.3: Power and Thermal Management Systems (PTMS)

RT-1.4: Vehicle Design

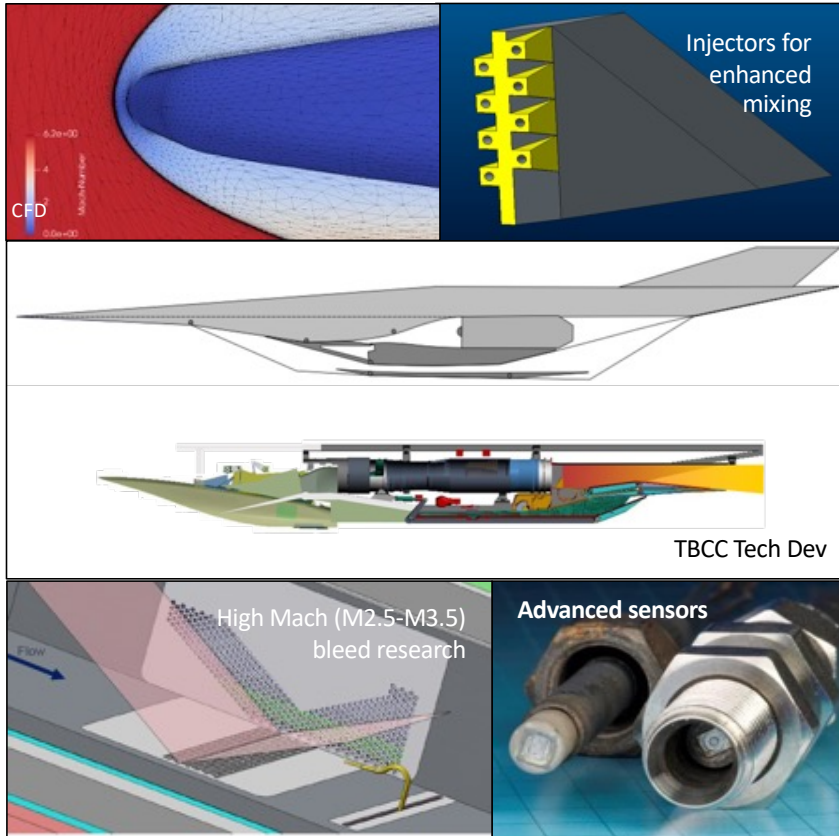
RT-1.5: Aerosciences Capability Development

RT-1.6: Design Fidelity Enhancement

Design and analyze civil-relevant reference vehicles and inform programmatic decision-making



RT-2: Propulsion Technologies



RT-2.1: Enhanced Injection and Mixing

RT-2.2: VULCAN-CFD Development

RT-2.4: Advanced Pressure Sensors for Adaptive Controls and Health Monitoring

RT-2.6: Isolator Dynamics Research Lab (IDRL)

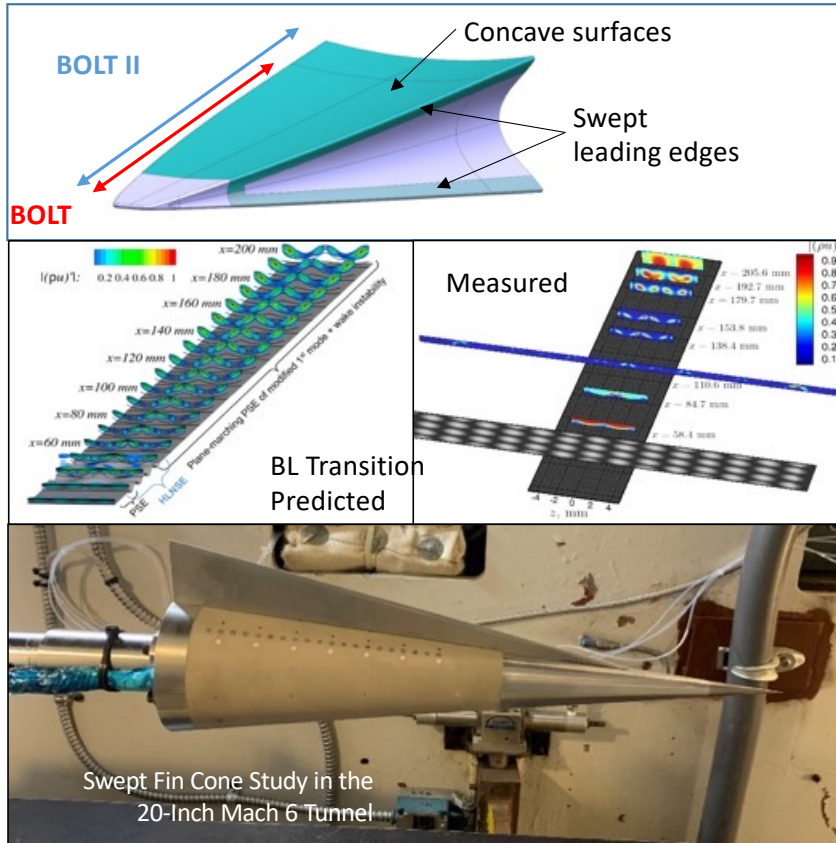
RT-2.8: Turboramjet Technology Development

RT-2.9: Aether Subscale Ground Test Propulsion Database Development

Maturing airbreathing propulsion technologies necessary for hypersonic TBC vehicles



RT-3: Vehicle Technologies



RT-3.1: Flight Testing / Program Support

RT-3.2: Boundary Layer Transition Validation and Computational Tools

RT-3.3: Fluid-Structure Interaction

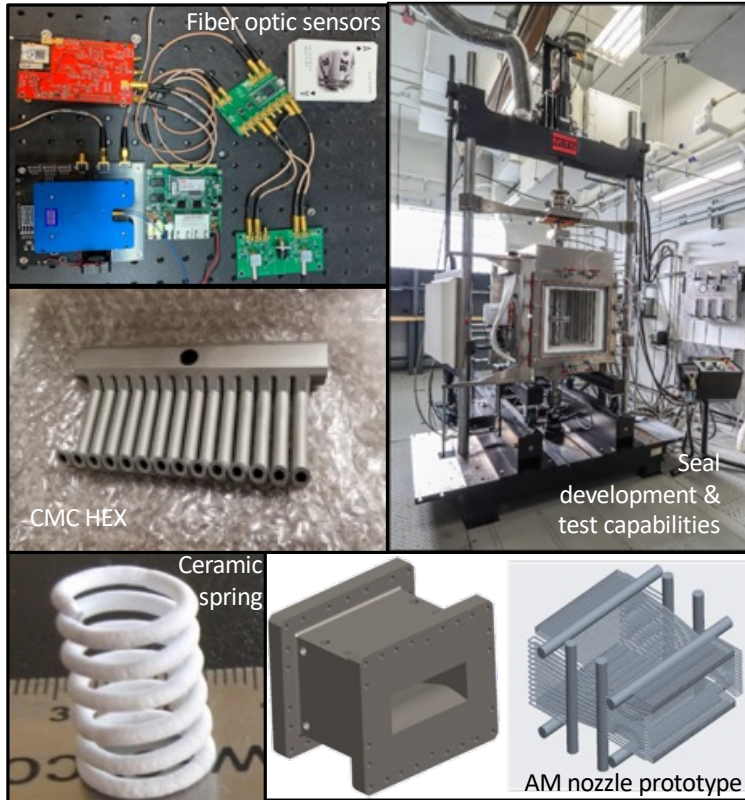
RT-3.4: Shock-Shock/Shock-Boundary Layer Interactions

RT-3.5: Flow Control Applications

Foster development of tools and technologies from fundamental to applied hypersonic vehicles



RT-4: High Temperature, Durable Materials



RT-4.1: Ceramic Matrix Composite (CMC) Heat Exchanger (HEX)

RT-4.2: High Temperature Seals

RT-4.4: Additive Manufacturing (AM) for Hypersonic Engines

RT-4.5: High-Temperature Fiber Optic Sensors

RT-4.6: Materials and Structures for Hypersonic Airframe Components

RT-4.7: Materials and Structures for Hypersonic Propulsion Components

Provide demonstrated high temperature material and component solutions/ data/ lessons learned to enable reusable hypersonic vehicles

Scientifically Calibrated in Flight Imagery (SCIFLI)



Who We Are

The Scientifically Calibrated In-Flight Imagery (SCIFLI) team is comprised of engineers, scientists, and subject matter experts with a proven track record of delivering flight-truth data sets to government, DoD, commercial, and international partners since 2003.

Capabilities include:

- Live video streaming
- Calibrated thermal imaging
- High-resolution & high-speed imaging
- Super resolution, image enhancement & deconvolution
- Hyperspectral / multispectral imaging

What We Do

SCIFLI is a success-oriented team that provides engineering datasets to help investigators truly understand the behavior of vehicles under extreme conditions. Our portfolio includes over 60 missions ranging in complexity across all flight regimes.

Example Flight Regimes Include:

- Subsonic and transonic drop testing
- Superorbital / deep-space sample return
- LEO and suborbital entry, descent, & landing
- Launch vehicle ascent, booster, & plume phenomena
- Launch abort, early-end-of-mission, flight termination sequence
- Upper atmospheric plasma and charged particle phenomenology

SCIFLI Will Design, Develop & Deploy Mission-specific Imaging Architectures To Meet Customer Needs

Ground-based



Sea-based



Airborne



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Summary of NASA Activities



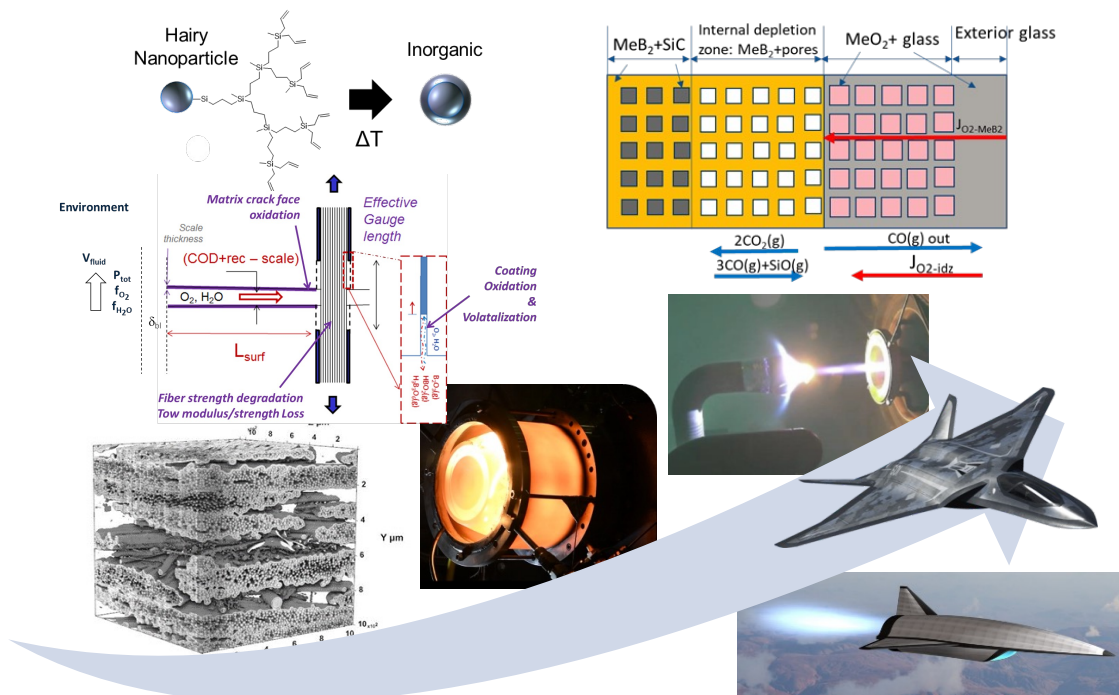
- NASA hypersonic investments are addressing major technical barriers
 - System analysis and uncertainty quantification
 - Propulsion technologies
 - Fundamental aerothermodynamic research
 - High temperature materials
- Strong partnerships and workforce development



Working to enable routine, reusable, hypersonic flight

AFRL Ceramic Materials and Processes Research

Develop, understand, and deliver ceramic technologies to enable future aerospace systems



Technical Thrust Areas

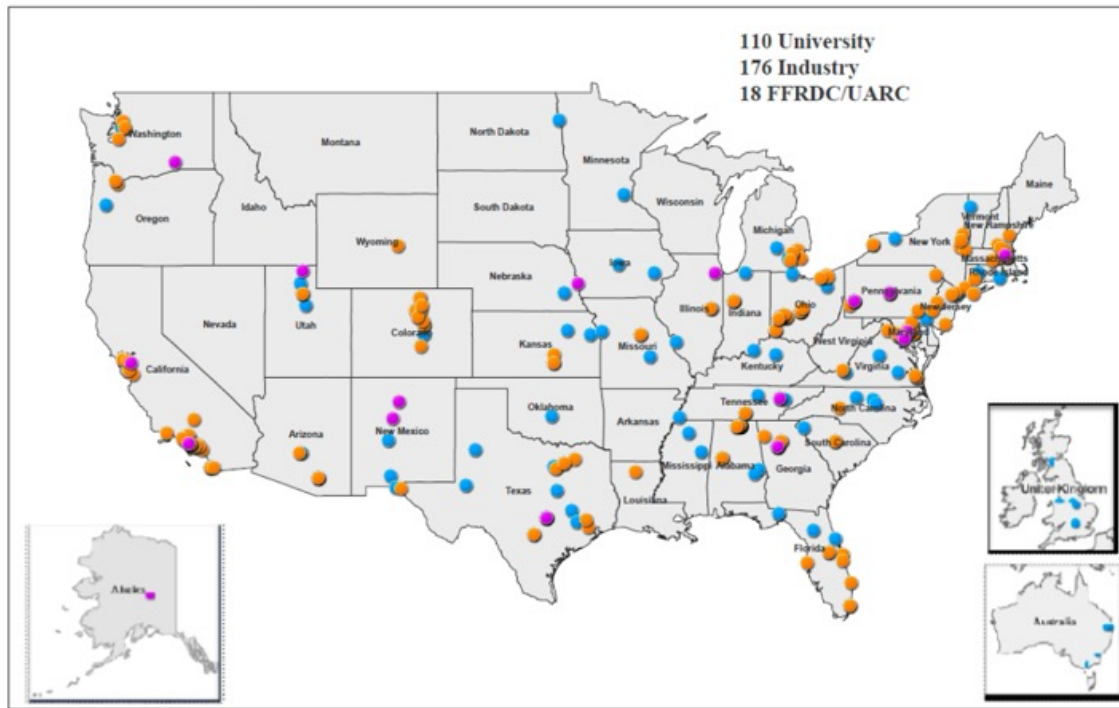
- CMC Constituent Development
 - Novel precursors
 - High-temperature matrices
 - Coatings
 - Process modeling
- Environmental Effects on CMCs
 - Degradation at constituent level
 - Simulated service environment
- Exploratory M&P
 - Additive manufacturing
 - Multifunctional ceramics



University Consortium for Applied Hypersonics (UCAH)



UCAH Membership



- Membership
 - 110 Universities (10 foreign universities)
 - 176 Industry Partners
 - 18 FFRDCs and UARCs
- Approved Participants
 - Professional 1,778
 - Grad Students 350
 - UG Students 218

FFRDC (Federally Funded Research and Development Center)

UARC (University Applied Research Center)

● UCAH Industry ● UCAH University ● UCAH National Lab/FFRDC/UARC

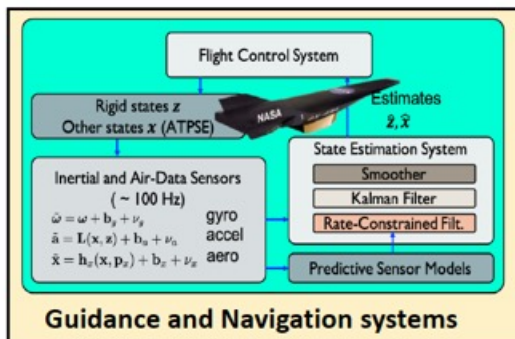
Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community 8/22/2023



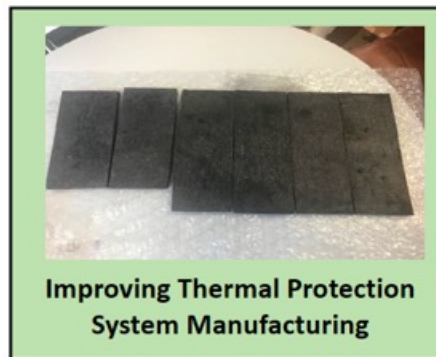
Examples of JHTO Projects (1 of 2)



Testing next generation seeker windows



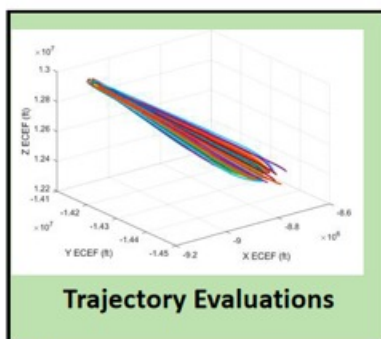
Guidance and Navigation systems



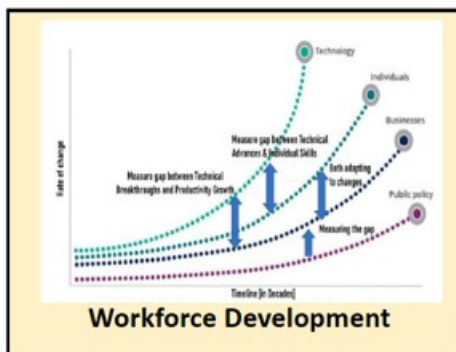
Improving Thermal Protection System Manufacturing



Ramjet propulsion technology



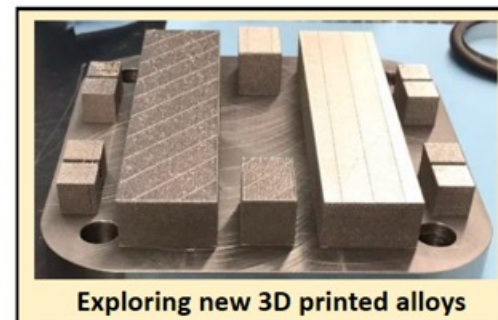
Trajectory Evaluations



Workforce Development



Wind Tunnel Testing



Exploring new 3D printed alloys

Legend

Acceleration

UCAH



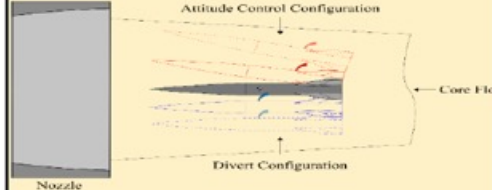
Examples of JHTO Projects (2 of 2)



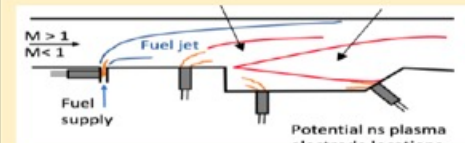
Developing data to support Warfighter & weapon employment



Understanding multi body dynamics at relevant speeds



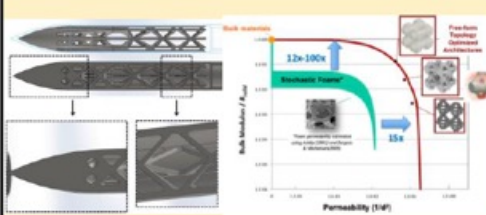
Establishing models to predict the control authority of different thrust configurations



Flame stability of air-breathing engines



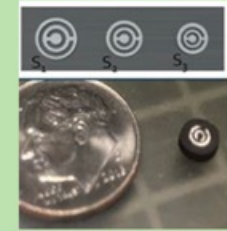
Understanding weather effects on weapon systems



Topology Optimization of materials



Health Monitoring of Aeroshells



Wireless sensor technology for monitoring engine performance

Legend

Acceleration

UCAH



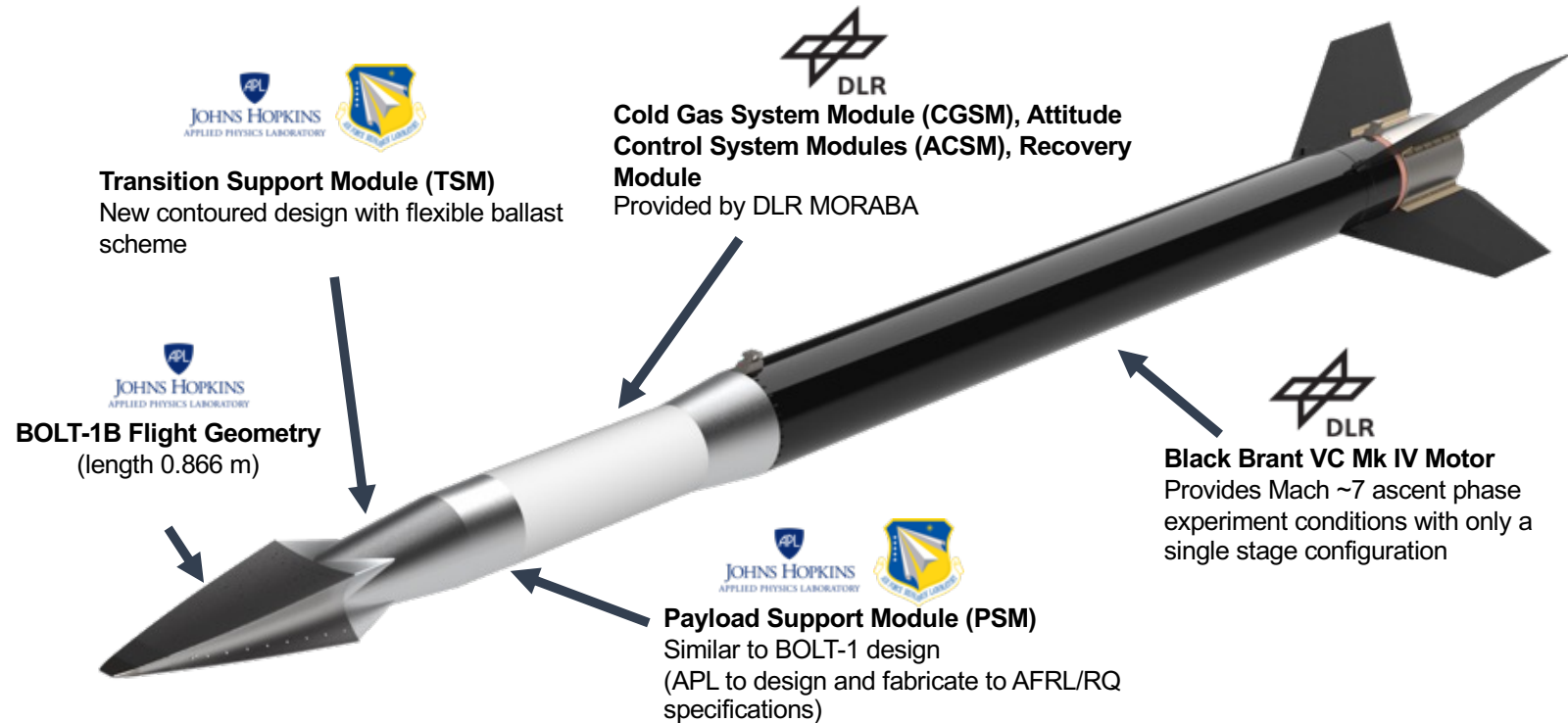
Boundary Layer Transition (BOLT)



- **The Boundary Layer Transition (BOLT) flight experiment research effort seeks to advance scientific knowledge of boundary-layer physics in the hypersonic regime**
- **Research prioritizes diverse teams including academia, a university affiliated research center, government, industry, and international partners**
- **Though the first BOLT flight experiment did not achieve the desired experimental conditions, it did result in:**
 - New experimental databases at ground conditions
 - New computational tool development for complicated hypersonic flows
 - Re-discovery of flight dynamics physics issues for asymmetric vehicles
 - Significant new workforce development through the inclusion of students in the program
- **A repeat of the flight experiment (BOLT-1B) is planned for 2024 in Australia**
 - BOLT-1B experiment will occur at Koonibba Test Range enabling potential payload recovery



BOLT-1B Flight Research Vehicle

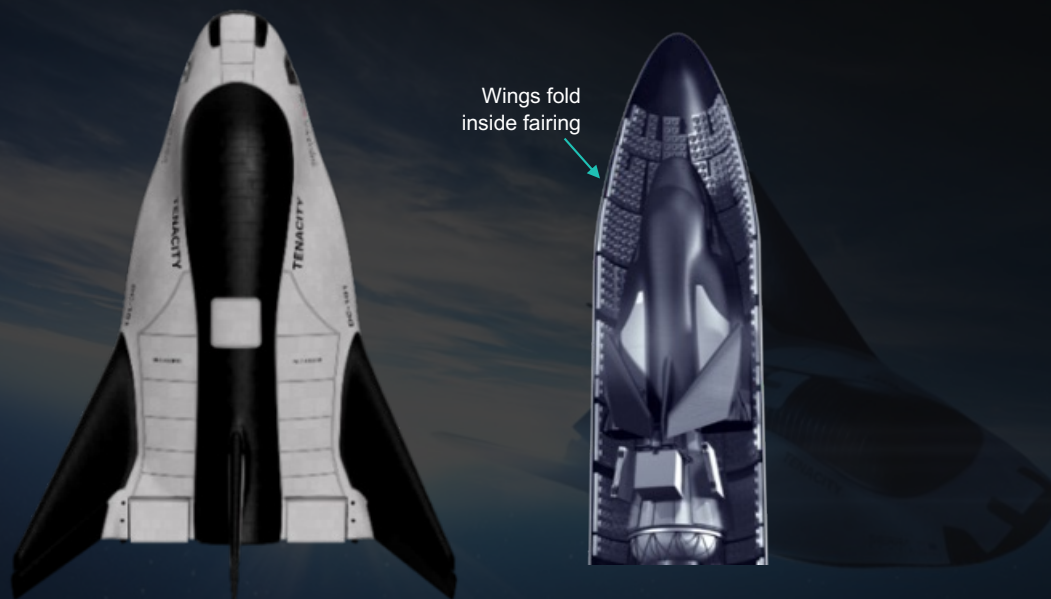


Stratolaunch Talon A Mission

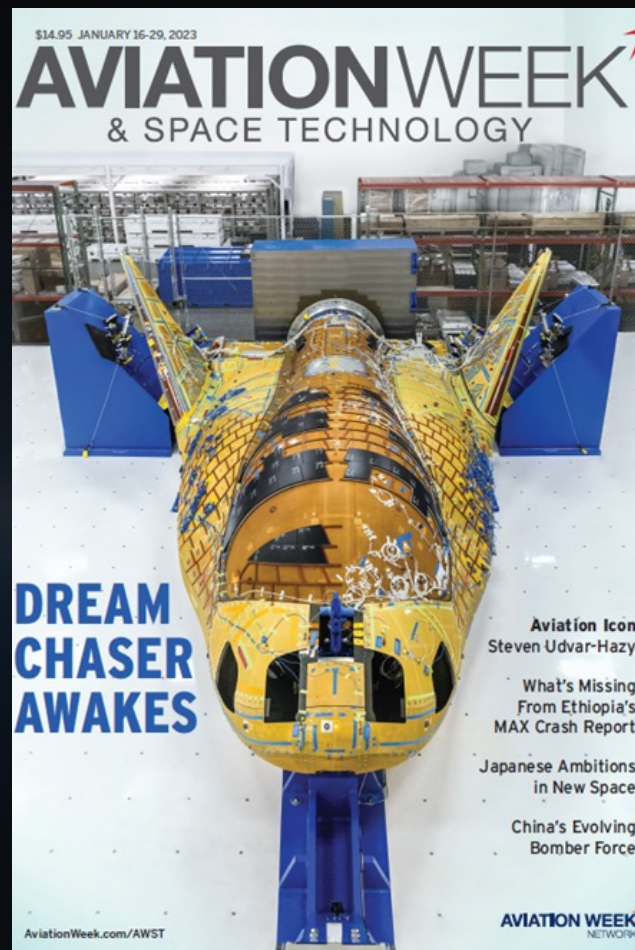
- Hypersonic testing and re-testing of hardware
- Onboard telemetry, data acquisition, and onboard power for experiments
- Payload recovery for customer analysis



CARGO DREAM CHASER



- 15+** Missions per Spaceplane – Highly Reusable
- 6+** Tons of Capacity for Pressurized and Unpressurized Cargo
- 1.5** G Force Upon Re-Entry
- 90** Day Cycle for Re-Flight



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US Air Force International Collaborations



- **Basic sciences – AFOSR investing world-wide (BOLT)**
- **SCIFIRE (Southern Cross Integrated Flight Research Experiment)**
 - Collaborative S&T for air-breathing hypersonic systems
- **AUKUS (Australia, United Kingdom, and United States) Pillar 2**
 - Developing a collaborative S&T project for future hypersonics
- **NATO (North Atlantic Treaty Organization)**
 - Multiple efforts in hypersonics and defense against hypersonics
- **Early discussions with multiple European and Asian partners**
 - Collaboration on applied technology for future capabilities
 - Collaboration on instrumentation, diagnostics, and controls for ground test facilities
 - Joint utilization of unique RDT&E infrastructure





Concluding Remarks



• Significant US efforts in hypersonics R&D

- NASA
- Air Force Research Lab (AFRL) ceramics research
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