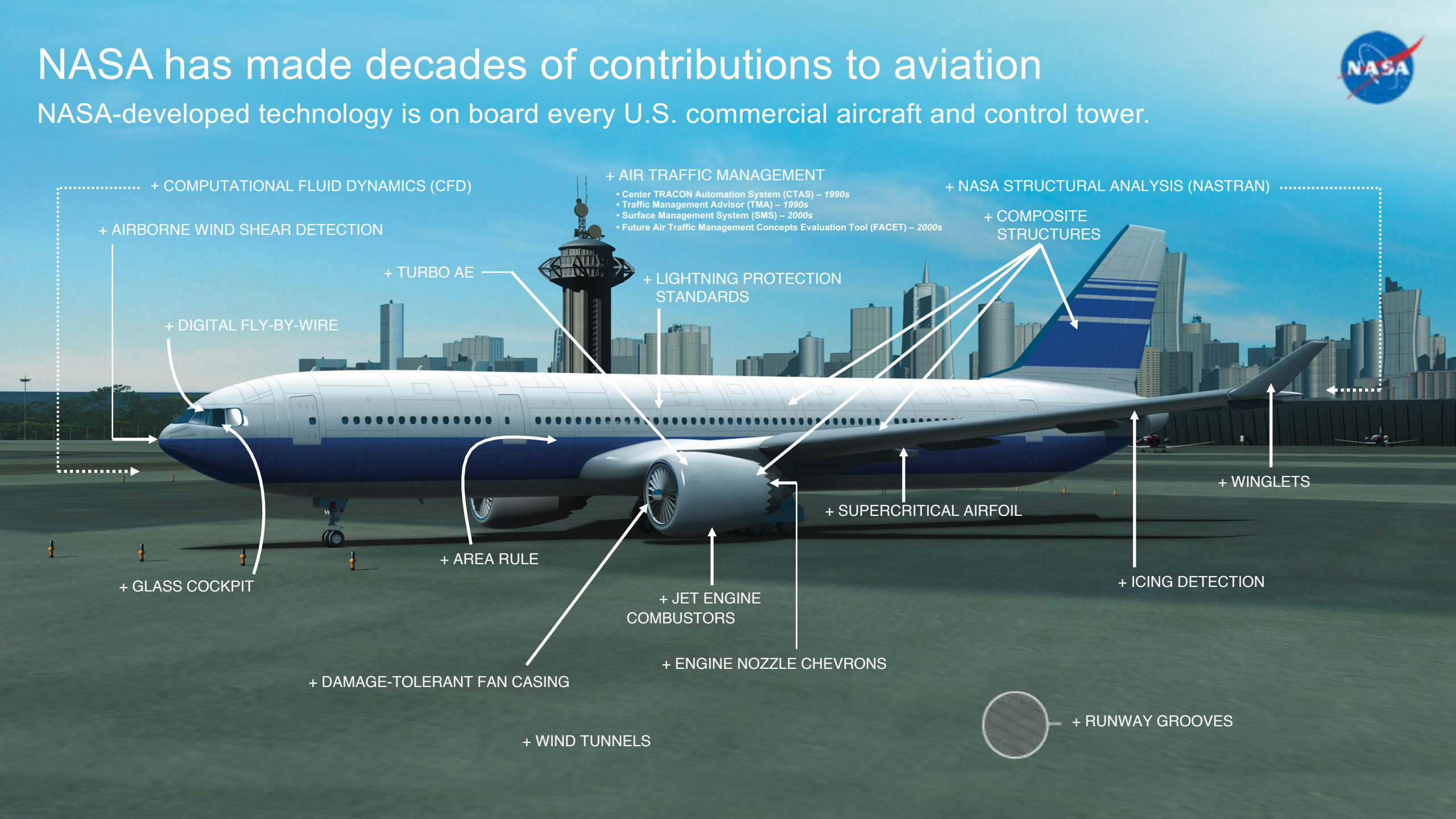


NASA Aeronautics Research

Dr. William (Bill) R. Van Dalsem
Deputy Director of Aeronautics
NASA Ames Research Center

NASA has made decades of contributions to aviation

NASA-developed technology is on board every U.S. commercial aircraft and control tower.



Aviation is vital to our nation's economy



- $88 billion positive trade balance
- $1.6 trillion total U.S. economic activity
- 10.6 million direct/indirect jobs
- $1.1 trillion spent by air travelers in U.S. economy
- 44 revenue ton-miles of freight transported by U.S. airlines

(Sources for statistics listed at https://www.nasa.gov/aero/infographics.html)

Global Growth in Aviation

Opportunities and Challenges



2017

4 BILLION

PASSENGER TRIPS

2036

7.8 BILLION

PASSENGER TRIPS

Airbus / Europe

Bombardier / Canada

Irkut / Russia

Comac / China

Embraer / Brazil

41,030
New Aircraft Deliveries

$6.1 Trillion
Market Value

Asia-Pacific Market is Nearly 40% of New Aircraft Deliveries

78%
of New Aircraft Deliveries are Single Aisle Class (including Regional Jets)

Global Competitors

NASA Aeronautics Strategies for Research

We are meeting global aviation challenges by using six research thrust areas to organize our research.









Safe, Efficient Growth in Global Operations

- Achieve safe, scalable, routine, high-tempo airspace access for all users



Innovation in Commercial Supersonic Aircraft

- Achieve practical, affordable commercial supersonic air transport



Ultra-Efficient Commercial Vehicles

- Realize revolutionary improvements in economics and environmental performance for subsonic transports with opportunities to transition to alternative propulsion and energy



Transition to Low-Carbon Propulsion

- Enable the use of alternative fuels and foster a fundamental shift to innovative aircraft propulsion systems that produce very low levels of carbon emissions relative to energy used.



In-Time System-Wide Safety Assurance

- Predict, detect and mitigate emerging safety risks throughout aviation systems and operations



Assured Autonomy for Aviation Transformation

- Safely implement autonomy in aviation applications

ARMD Research Programs & Projects Align with ARMD Strategy

MISSION PROGRAMS

AIRSPACE OPERATIONS & SAFETY

AOSP



PROJECTS

ATM Tech Demonstrations

UTM

ATM-X Project

System-Wide Safety

ADVANCED AIR VEHICLES

AAVP



PROJECTS

Advanced Air Transport Technology

Commercial Supersonic Technologies

Revolutionary Vertical Lift

Advanced Composites

Hypersonic Technology

Aerosciences Evaluation & Test Capabilities

INTEGRATED AVIATION SYSTEMS

IASP



PROJECTS

UAS in the NAS

Flight Demonstrations and Capabilities

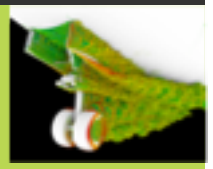
Low Boom Flight Demonstrator

Integration and Flight

SEEDLING PROGRAM

TRANSFORMATIVE AERONAUTICS CONCEPTS

TACP



PROJECTS

Convergent Aeronautics Solutions

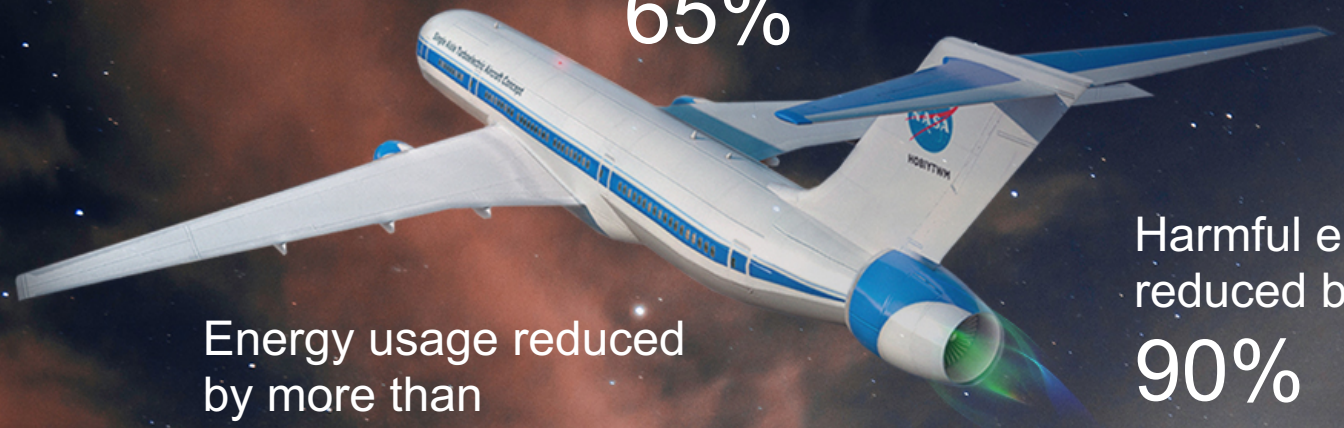
Transformational Tools and Technologies

University Innovation and Challenges

Convergent Innovation and Revolutionary Analysis Tools

Objectionable noise reduced by more than

65%



Harmful emissions reduced by more than

90%

Energy usage reduced by more than

60%

HYBRID ELECTRIC

AAVP

PROJECTS



Advanced Air Transport Technology

Commercial Supersonic Technologies

Revolutionary Vertical Lift

Advanced Composites

Hypersonic Technology

Aerosciences Evaluation & Test Capabilities

FROM SONIC BOOM TO SONIC "THUMP" OVER LAND

PROJECTS



UAS in the NAS

Flight Demonstrations and Capabilities

Low Boom Flight Demonstrator


URBAN AIR MOBILITY
AOSP
PROJECTS
ATM Tech Demonstrations
UTM
ATM-X Project
System-Wide Safety

AERODYNAMICS

COMMUNICATION

VERTICAL LIFT

SOFTWARE

GPS

COMPUTER

BATTERIES

IMAGING

TACP

PROJECTS



Convergent Aeronautics Solutions

Transformational Tools and Technologies

University Innovation and Challenges

NASA Ames Research Center

- Aeronautics Connection -



Ames is One of the Early NACA Laboratories



Joseph S. Ames



NACA

Langley

Ames

Lewis

Dryden

NASA

1915

1931

1939

1940

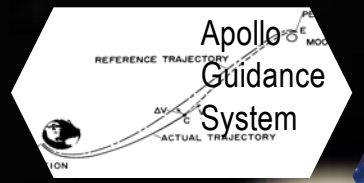
1946

1958

Moffett Field

80 Years of Innovation











2015











2000

1990











1980

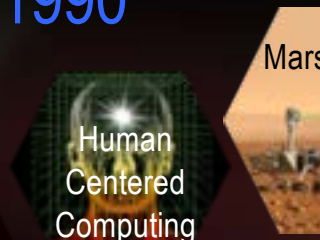






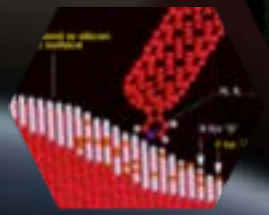


1970

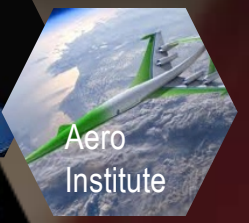










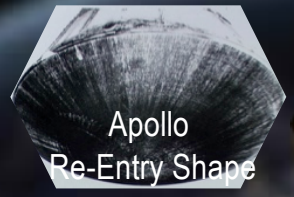
















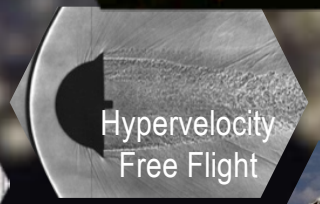






1950









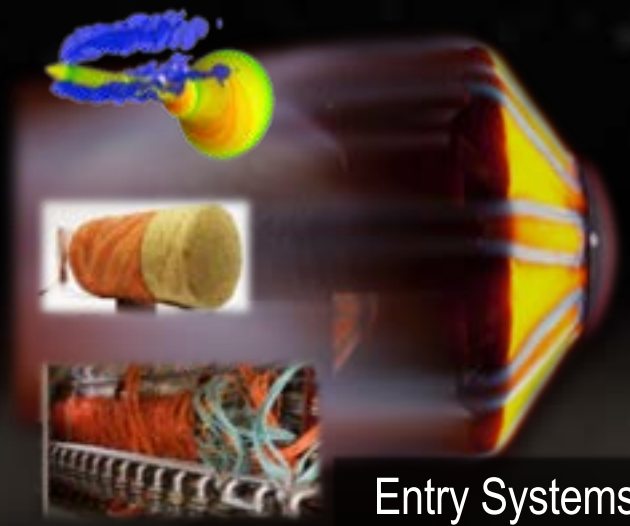


1940

Core Competencies at Ames Today



Air Traffic Management



Entry Systems



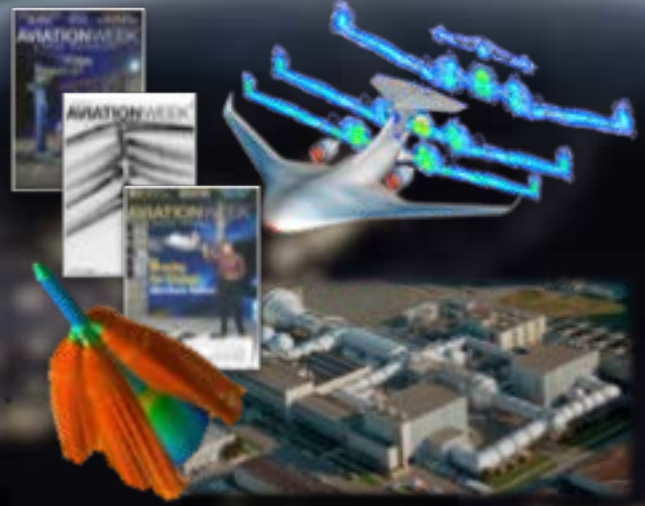
Advanced Computing & IT Systems



Intelligent/ Adaptive Systems



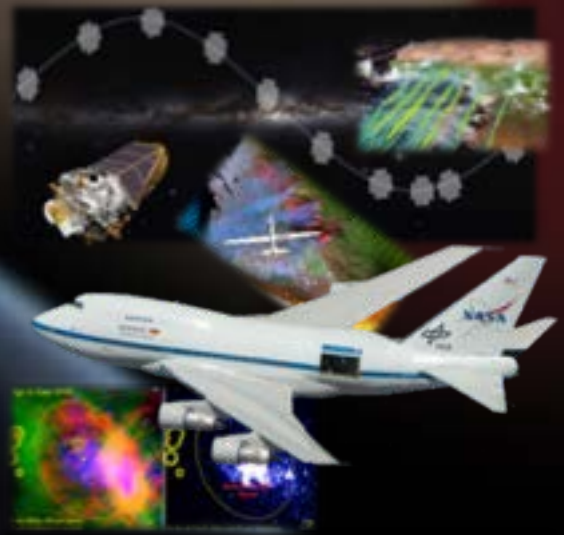
Cost-Effective Space Missions



Aerosciences



Astrobiology and Life Science

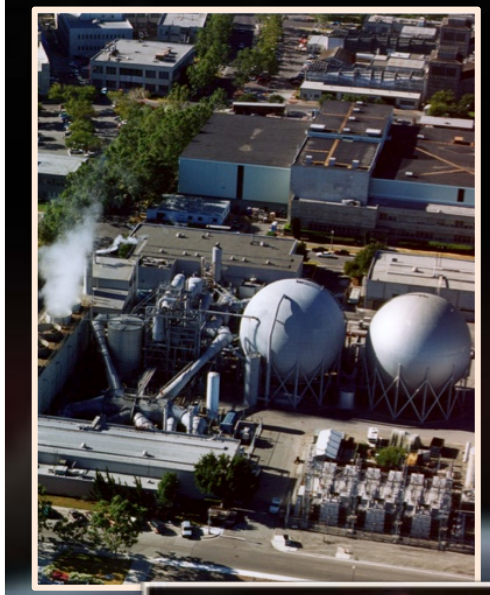


Space and Earth Sciences

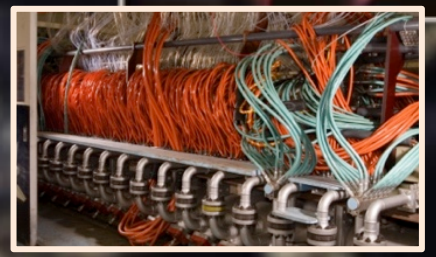
Major Research Facilities



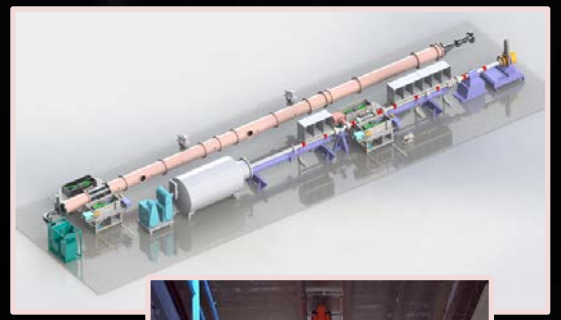
Wind Tunnels



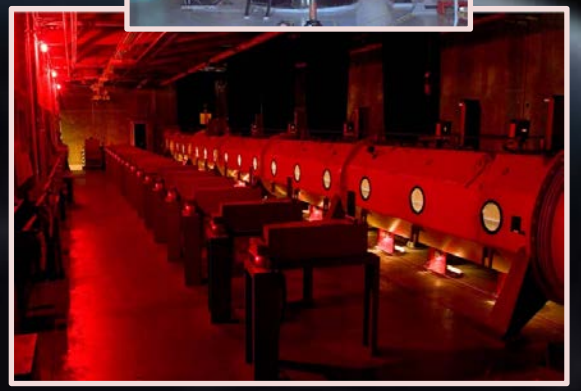




ARC Jet Complex





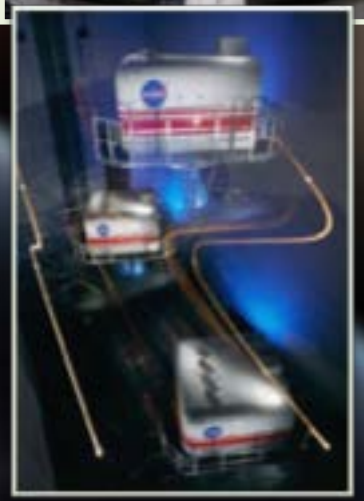


Range Complex









Simulators

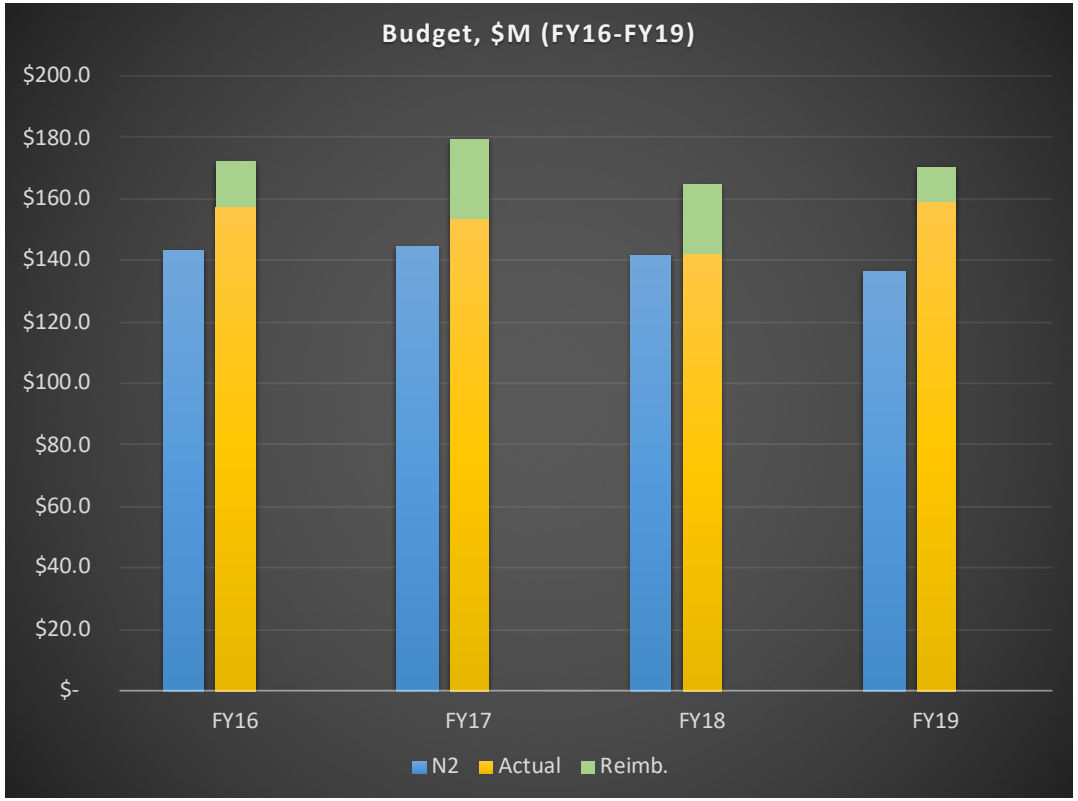


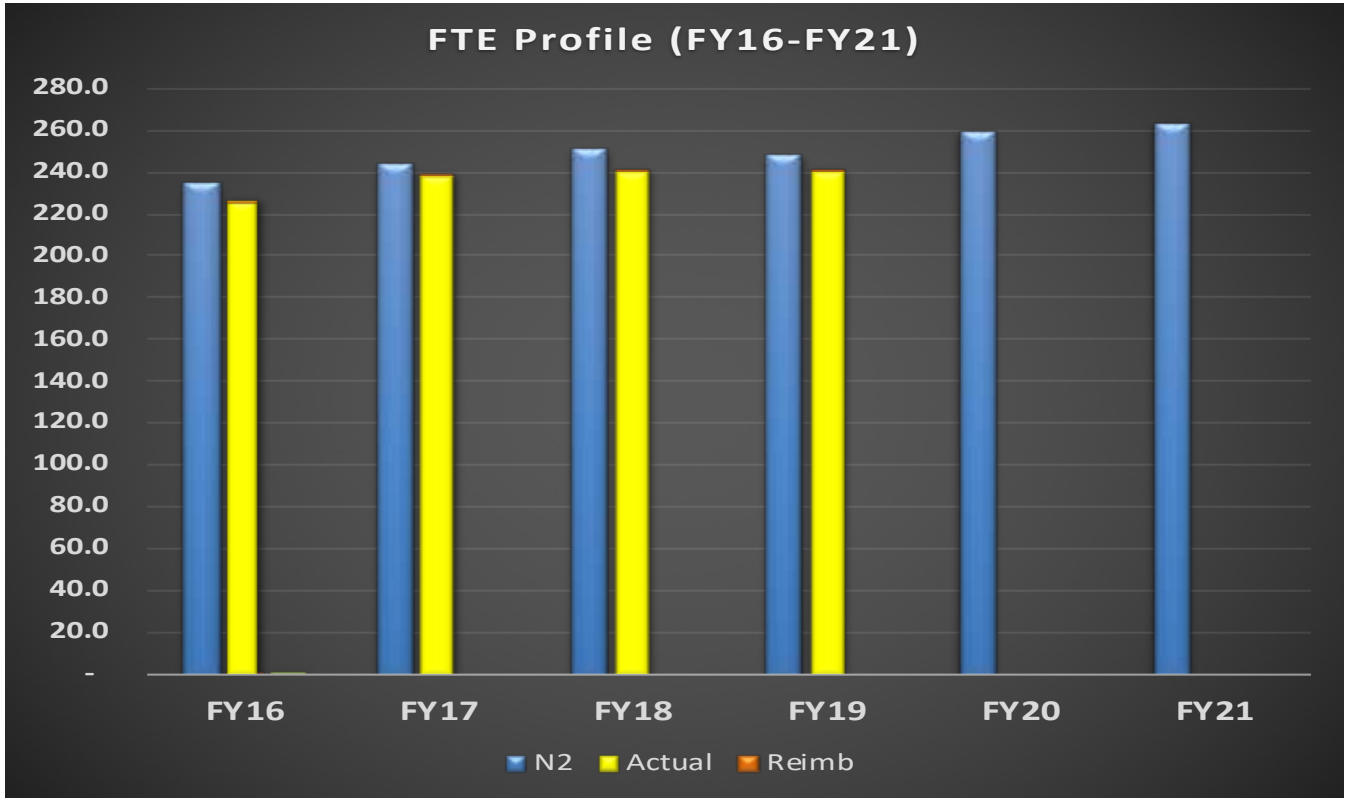




Advanced Supercomputing

Ames Aeronautics Budget & FTE (Civil Servant) Profiles





Aeronautics at Ames Transformation

Current Contents

- ATM/Airspace Tech Demo
- UAS Traffic Management
- UAS in NAS
- System-Wide Safety (V&V)
- Vertical Lift Technologies
- CAS/Autonomy
- Aeroscience
- CAS/Quantum for Secured ATM
- SMART-NAS Test Bed (Simulation Capability)

Transformation

Future State: New Entrants

- UTM-inspired ATM, service-oriented architecture, self-management)
- Urban Air Mobility - Autonomous
- Secured ATM/Intelligent Airspace
- eVTOL
- In-Time Safety Systems Monitoring

Future State: Traditional

- **Integrated Digital Airspace Management**
- **X-Plane: LBFD, UEST/EAP**
- **Urban Air Mobility – Piloted**
- **System-Wide Safety – Prognostics/Diagnostics/Response**

Test Bed and Real Time System Monitoring

Strong shift to large number of heterogeneous vehicles (including autonomous V/STOL) operating in an autonomous airspace (UTM-inspired) may require rethinking of separate ATM, Autonomy, and Aerosciences Core Competencies

Recent Aeronautics Highlights

UTM TCL 4 Flight Demonstrations, Summer 2019

Objective

- Demonstrate the UTM system managing high density drone traffic in urban environments under varying conditions



Approach

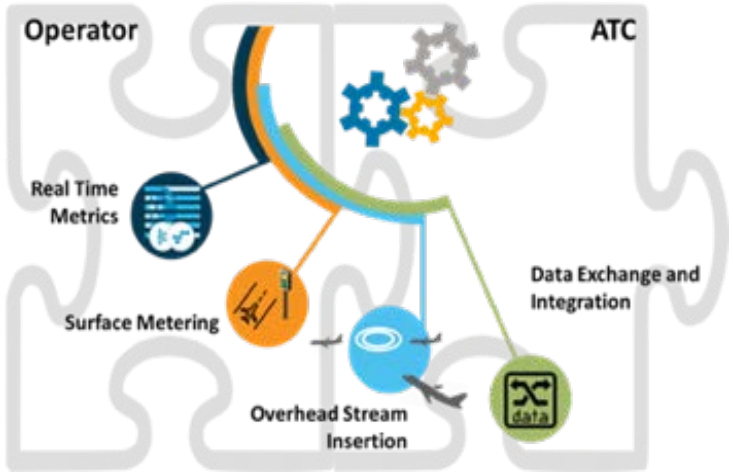
- Fly live and simulated drones in downtown areas of Reno, NV and Corpus Christi, TX
- Drones outfitted with advanced command and control, navigation, detect and avoid, vehicle to vehicle communication, and safe landing technologies





ATD-2 Integrated Arrival/Departure/Surface (IADS)

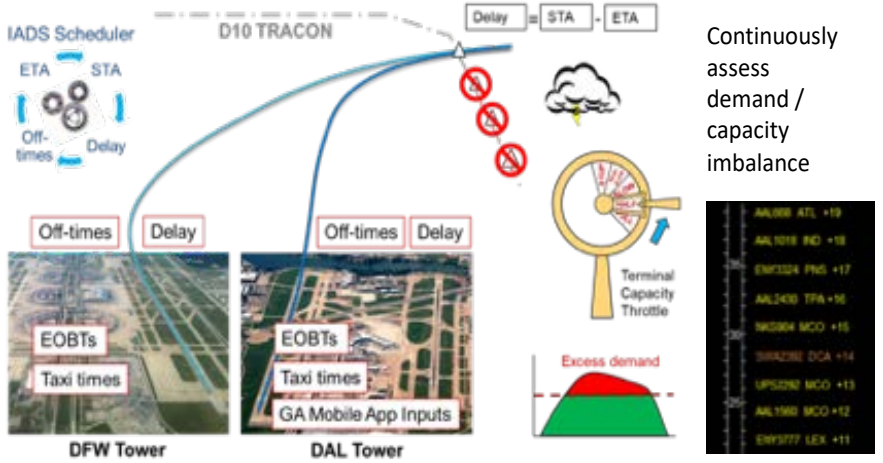
Phase 2 Continues in CLT



NASA's ATD-2 Single-Airport IADS demo is a pathfinder for the FAA's Terminal Flight Data Manager (TFDM) Program

- The TFDM concept depends on close collaboration between ATC and Operators
- TFDM will provide tools for ATC, but only data for Operators
- The ATD-2 IADS system implements ***both*** ATC and Operator ***pieces of the puzzle***
- ATD-2 is transferring Technology and Knowledge to ***both*** FAA and Industry (operators and vendors)

Phase 3 Commences in North Texas



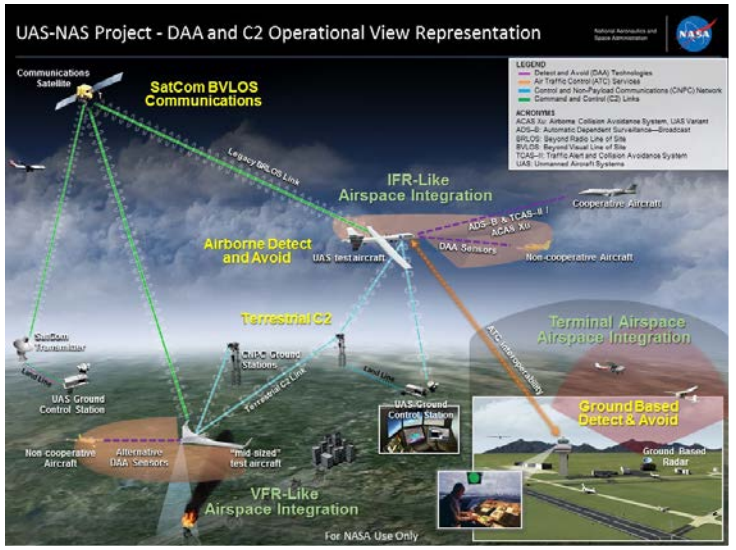
Continuously assess demand / capacity imbalance

NASA's ATD-2 Multi-Airport IADS system builds on the Phase 2 foundation to provide an IADS solution for the Metroplex

- A key element of Phase 3 is the application of Trajectory Option Sets (TOSs) to departures
- The Phase 3 evaluation commenced on June 10th with increments planned for mid-July and mid-August
- Summer 2019 is an Initial Concept Evaluation to prepare for the Phase 3 Operational Evaluation in 2020
- Southwest Airlines and DFW Airport join American Airlines, FAA, and NATCA as Field Demo Partners for Phase 3

Unmanned Aircraft Systems (UAS) Integration in the National Airspace System (NAS)

Making UAS Access into the National Airspace a Safe Reality



Objective: Conduct tests to identify and reduce technical barriers related to safety and operational challenges when integrating UAS into the NAS

Explore solutions to two technical challenges:

- Detect and Avoid (DAA)
- Command and Control (C2)

The UAS-NAS Project is supported by NASA Ames, Armstrong, Glenn, and Langley Research Centers

Approach:

Phase 2, FY17-FY20

- Flight Test 6: AFRC, OCT 2019
- Utilize simulation and flight tests in support of Phase 2 Minimum Operational Performance Standards (MOPS)
- Systems Integration and Operationalization (SIO) demonstration of UAS operations in the NAS employing DAA, C2, and other vehicle/airspace operations technologies that inform FAA UAS integration policies and operational procedures

Flight Test 6:

- Low Space, Weight and Power (SWaP) RADAR
- Low SWaP Well Clear Definition
- Tiger Shark Aircraft, Vigilent Spirit Ground Control Station





ATM-X



Vision: Increased mobility and connectivity in a digitally-integrated environment by transforming the air transportation system



Aug/Sep 2019: Test Urban Air Mobility airspace management system for use in future field activities



RVLT: Tiltrotor Test Rig (TTR) – Complete in FY19

PROBLEM NASA needs a facility for testing 21st-century proprotors. No wind-tunnel data exist at full speed (250+ knots) for a full-scale proprotor. There is no capability to test new proprotor concepts at large scale; the most recent data are over 25 years old.

OBJECTIVE Fill the gaps in understanding of proprotor performance by collecting data for (1) hover up to and beyond stall, (2) axial flow up to 300 knots, and (3) helicopter and transition modes. Add capability to test slowed rotors in cruise for efficiency and in hover for low noise.

APPROACH Build a new Tiltrotor Test Rig (TTR) capable of 300 knots, 30,000 lb thrust, with 6000 HP installed. Initial checkout testing will use a 26-ft diameter rotor.

ACCOMPLISHMENTS

- Acquired baseline hover data.
- Airplane-mode thrust sweeps up to 264 knots—a new record! (40x80 limit with 12-bladed fan drives).
- Thrust sweeps over most of the rotor conversion envelope.
- Acquired acoustics reference data at all test points.
- Acquired control response data at ~½ of test points.

SIGNIFICANCE

- A new test rig is available for proprotor performance measurements at improved power, speed, and accuracy.
- Advanced tiltrotor concepts have been proposed by Bell for Future Vertical Lift and by Karem (a new Uber partner) for Urban Air Mobility



Bell 280 Valor





Karem Butterfly Quad Tiltrotor

Partners: Army ADD, Air Force; Prime Contractor: Bell

ARC UPWT
Stator Shift Outage Major Projects

MDSC Controllers

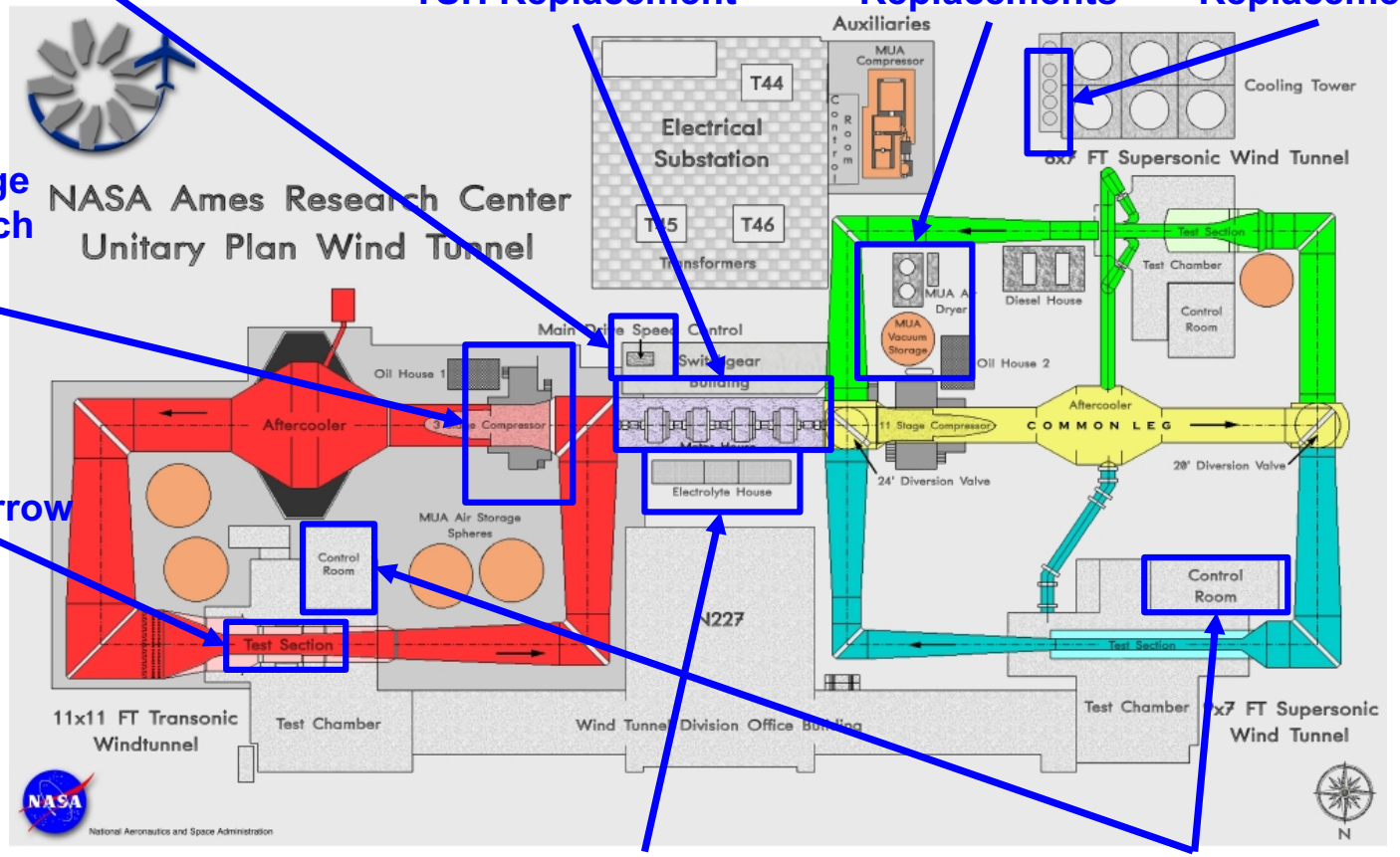
M1&3 Stator Shift & Bearing TSH Replacement

Valve Replacements

CW Stub Pipe Replacement

Blade Change & Hatch Install

TS of Tomorrow

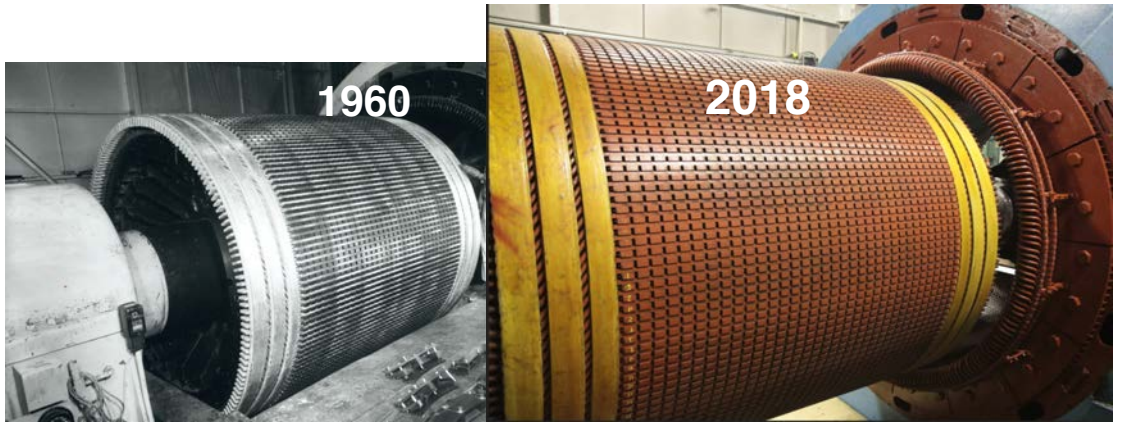


Rheostat Tank Repair

CR Instrument Power Upgrade

UPWT DRIVE TRAIN

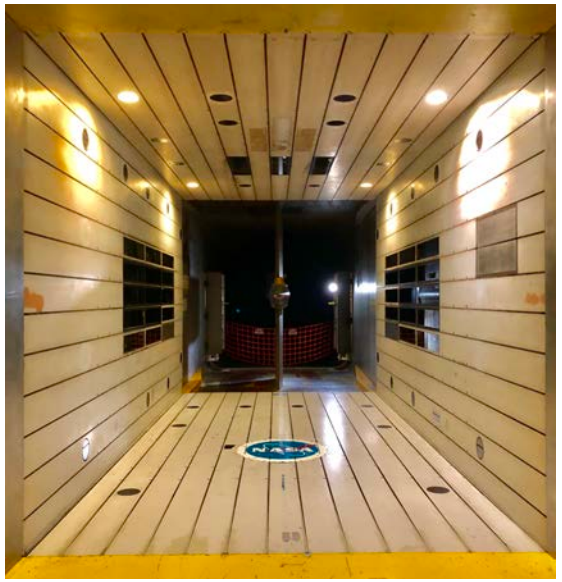
- 176 MW Total Available Power
- Four 65,000 hp Wound Rotor Motors
- Common shaft with 24-inch bearings
- Completed refurbishment of Stators M1, M2, M3, & M4 during furlough
- Perform LEAP (ABB) tests on all four motors



Test Section of Tomorrow Completed

- 38 new windows for flow viz ; e.g., PSP, IR thermography
- New hatches allow rapid reconfiguration of optical systems

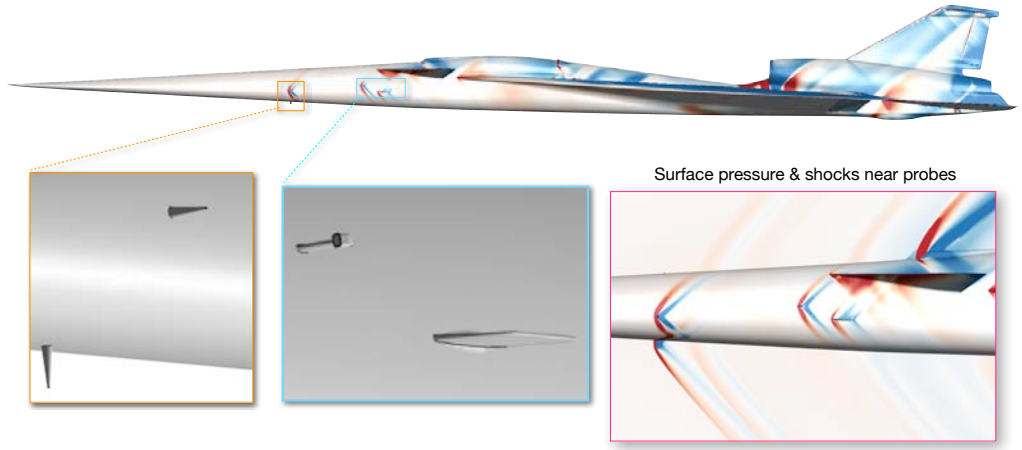


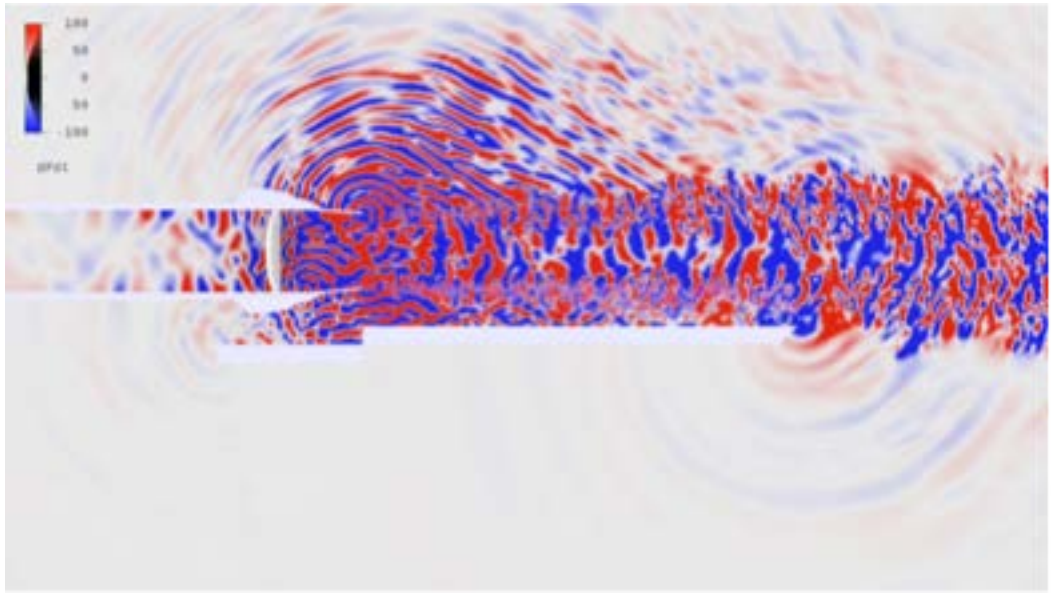


- Better tomographic Background-Oriented Schlieren to achieve 3D time-resolved view of shock waves

LAVA Team supports Low Boom Flight Demonstrator – X-59

- Cart3D and LAVA CFD identified major design issues for X-59's nose
- Enabled rapid redesign of the aircraft and was sent to Lockheed Martin team for prior to manufacturing process
- Significant cost saving to LBFD built





- Developed hybrid RANS/LES methods to address jet noise of full flight configurations
- Predicted jet surface interaction noise accurately.

Aeronautics CFD

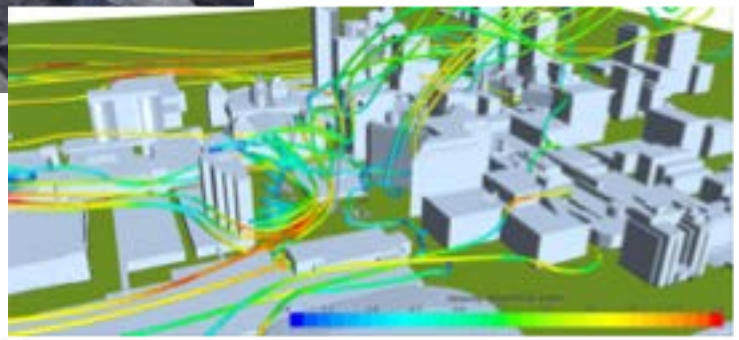


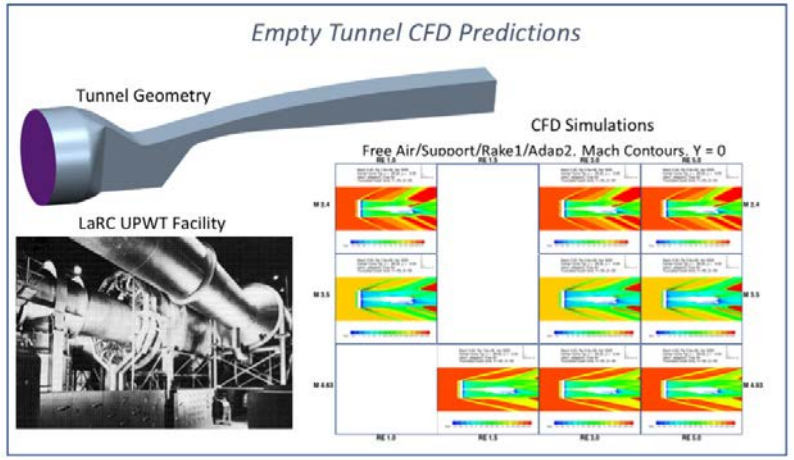
STMD - Pterodactyl ECI Project



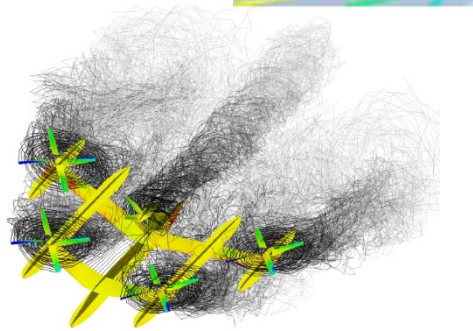
UTM/UAM - Urban flow simulations

- Geometry creation tools for generating 3D city models
- Wind database for SF, Reno



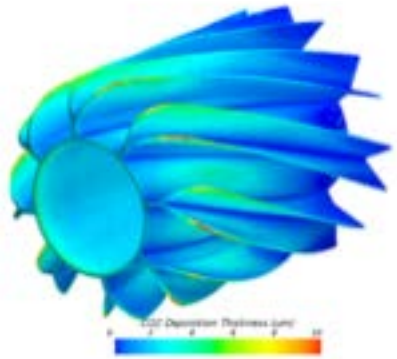


AETC - Evaluation of CFD as Surrogate for High-Speed Wind Tunnel Testing



TTT –VIPER MDAO

- VSPAERO updated for unsteady, time-accurate analysis
- Unsteady VSPAERO coupled with PSU-WOPWOP



ESMD - CO_2 Deposition on Cold Fin

Future Directions

Data & Reasoning Fabric (for Aeronautics)

SMART VEHICLES

SMART AIRSPACE



001 1000



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001 1000

SMART CITIES

Data & Reasoning Fabric (for Aeronautics)

SMART AIRSPACE



SMART VEHICLES



SMART CITIES



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Attributes

- All relevant real-time knowledge available where decisions need to be made.
- Seamless sharing of reasoning & actions between humans & machines.
- Continual progress towards distributed & edge data collection, sharing, and reasoning.

Opportunities

- Retain current levels of safety even with increased air travel density and complexity.
- Optimized transportation
  - Door-to-door (rather than gate-to-gate)
  - Multi-modal (ground, sea, air)

Data & Reasoning Fabric (for Aeronautics)

SMART AIRSPACE



SMART VEHICLES



SMART CITIES



001 1000 1100 0001110 001 1000

Enabling Technologies

- Real-time heterogenous data aggregation & knowledge extraction and sharing.
- Transparent machine reasoning with human insight/oversight capable of safely resolving complex contingencies.
- Cloud-to-the-Edge sensors & reasoning systems.

System-Level Challenges

- Autonomous decisions in complex environments.
- Cybersecurity of distributed safety critical systems.
- Complex system-of-smart systems engineering.

Questions?