# ARMD Fundamental Aeronautics Program

**Green Aviation Summit**
**Fundamental Aeronautics Program**
**NASA Ames Research Center**
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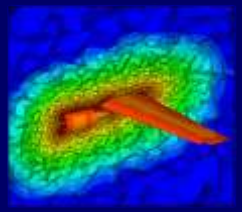
# ARMD Programs

## Vehicle



Fundamental Aeronautics ($228M)

Integrated Systems Research ($113M)

## Operations

Airspace Systems ($82M)

## Supporting

Aviation Safety ($79M)


Aeronautics Test ($76M)

# Fundamental Aeronautics Program Focus

Develop capabilities necessary to address national challenges in air transportation including noise, emissions, fuel consumption, acceptable supersonic flight over land, mobility, and the ability to ascend/descend through atmospheres.

# Program Organization

***Subsonic Fixed Wing (SFW)***: Develop improved prediction methods and technologies that enable dramatic improvements in noise and emissions reduction, and increased performance characteristics of subsonic/transonic aircraft.

***Subsonic Rotary Wing (SRW)***: Radically improve the transportation system using rotary wing vehicles by increasing speed, range, and payload while decreasing noise and emissions.

# Program Organization

***Supersonics:*** Eliminate environmental and performance barriers to practical supersonic transportation (sonic boom and airport noise, emissions, cruise efficiency).

***Hypersonics***: Enable airbreathing access to space and high mass entry into atmospheres.

# The National Policy and Plan

– "Assuring energy availability and efficiency is central…" and "The environment must be protected…"



# Energy and Environmental Challenges

1. **Fuel Efficiency**
2. **Emissions**
3. **Noise**

# New Vehicle Capabilities Needed for NextGen

- Energy and efficiency challenges will require much greater performance from future aircraft
- These future aircraft also bring opportunities for greater air mobility options
- Integrating new vehicles with future operations is critical
- NASA research is enabling these new vehicles by developing new knowledge and technologies that allow others to design and build future air vehicles.

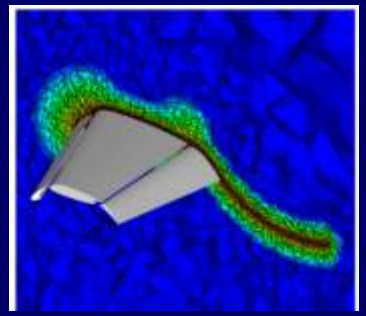
# Wide Range of Research

Support to System Development

Experimental Vehicles

Novel Technologies and Materials

Experimental Data



Foundational Research

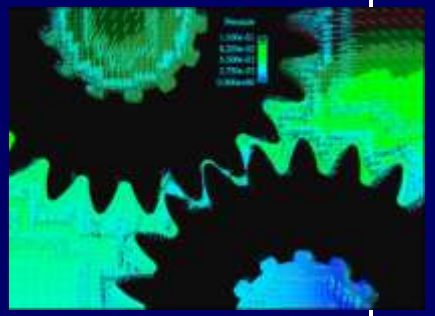
Future Concepts

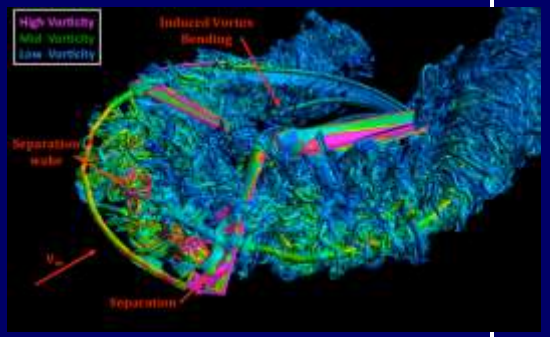
Publications and Databases

# Rotorcraft Environmental Challenges

Integrated Aeromechanics/Propulsion System:

- Enables very high-speed, efficient cruise; efficient hover; reduced noise, increased range






Actively-Controlled, Efficient Rotorcraft:

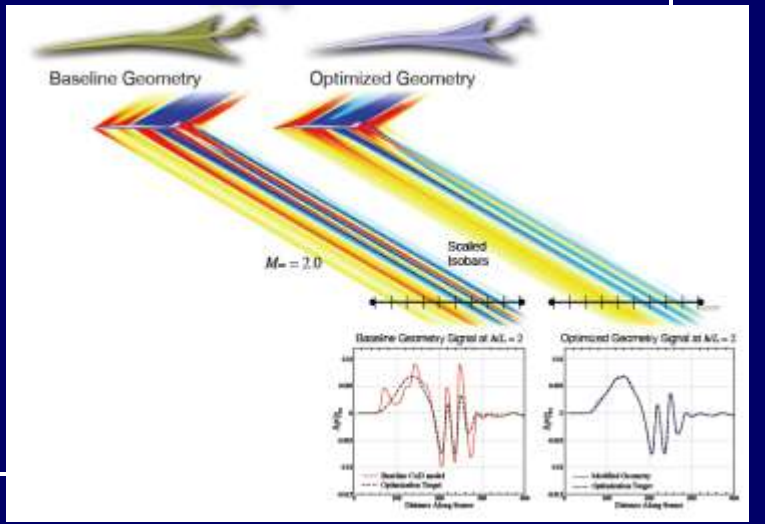
- Simultaneously increase aerodynamic efficiency, control dynamic stall, reduce vibration, reduce noise

# Supersonics Envrironmental Challenges

Environmental Challenges - No greater impact than subsonic fleet

- Sonic Boom
- Airport Noise
- High Altitude Emissions

Efficiency Challenges -Achieve low sonic boom with a 30 % greater L/D than High Speed Research low boom concepts

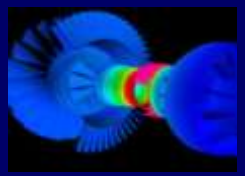


# Subsonic Fixed Wing

**Explore and Develop *Tools, Technologies, and Concepts* for *Improved Energy Efficiency and Environmental Compatibility* for Sustained Growth of Commercial Aviation**

**Objectives:**

- Prediction and Analysis tools for reduced uncertainty
- Concepts and technologies for dramatic improvements in noise, emissions and performance



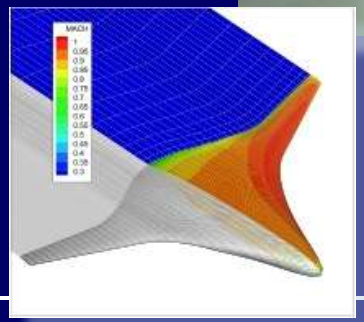
**Technologies, Tools and Knowledge**

# Subsonic Challenges

Environmental Challenges
- Reduce Perceived Noise
- Reduce Harmful Emissions

Efficiency Challenges
- Reduce Drag
- Reduce Weight
- Reduce Thrust Specific Energy Consumption

Cross-cutting Challenges
- Leverage NextGen Capabilities in Aircraft Design
- Improved Tools and Methods



# NASA Subsonic Transport System Level Metrics

*…. technology for dramatically improving noise, emissions, & performance*

| CORNERS OF THE TRADE SPACE | N+1 (2015)*** Relative to Single Aisle Reference | N+2 (2020)*** Relative to Twin Aisle Reference | N+3 (2025)*** |
|---|---|---|---|
| Noise (cum below Stage 4) | -32 db | -42 db | -71 db |
| LTO NOx Emissions (below CAEP 6) | -60% | -75% | Better than -75% |
| Performance: Aircraft Fuel Burn | -33%** | -50%** | Better than -70% |
| Performance: Field Length | -33% | -50% | Exploit metroplex* concepts |

*** Technology Readiness Level = 4 - 6:
** Additional potential gains from operational improvements
* Optimal use of available runways in metropolitan areas.

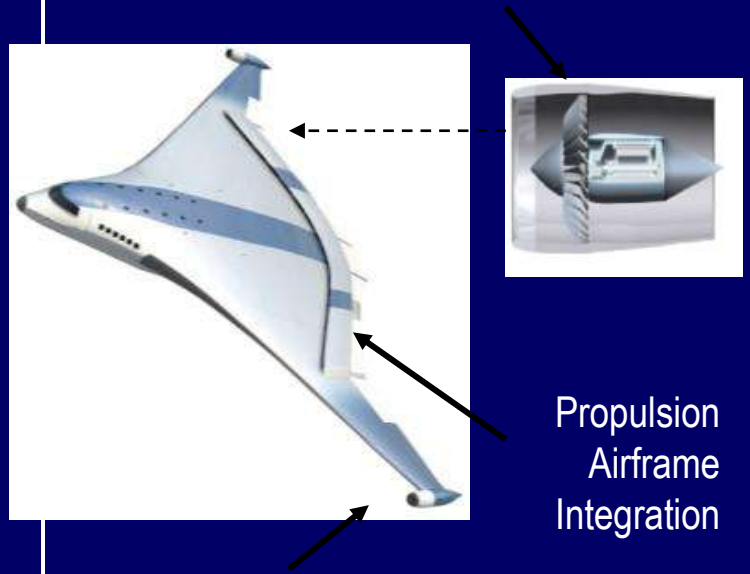
# SFW N+3 Advanced Concepts Studies

- Four 18-Month Studies for Transport Aircraft Entering Service in 2030-35
- Trends
  - Lower cruise speeds at higher altitude (~40-45k ft)
  - Heading toward BPR 20 with small, high efficiency core
  - Higher AR and laminar flow to varying degrees
- Uniquely enabling concepts/techs emerged
- Broadly applicable technology advances needed
- Energy: conventional/biofuel most prevalent, plus hybrid electric

# SFW In-House N+3 Studies

## Distributed Turboelectric Propulsion

Lightweight High Temperature
Superconducting Components



Propulsion
Airframe
Integration

Turboelectric Engine Cycle

## Truss-Braced Wing (TBW) Research

Partnership with Virginia Tech, Georgia Tech

High Span Truss-Braced Wing with Fold
Goldschmied Propulsor

Laminar Flow

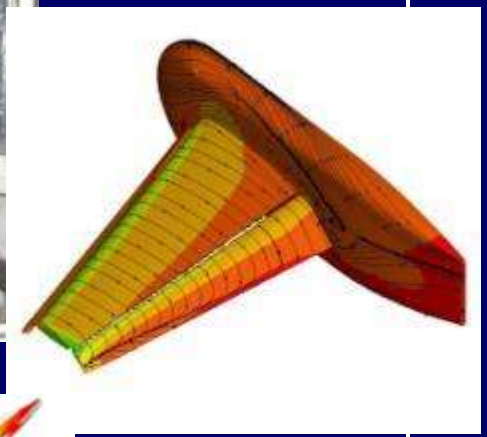
# Aviation Alternative Fuel EXperiment (AAFEX)

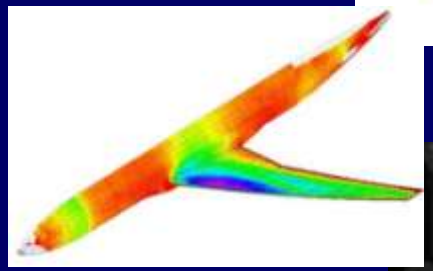
- Effect of Fischer- Tropsch Synthetic Fuels (CTL and GTL) on aircraft engine emissions plume chemistry
- F-T fuels tested at 100% synthetic and 50/50 blend with emissions sampling.
- Particulate and gaseous emissions data obtained.


# CFD Prediction Capabilities

- **1st AIAA CFD High Lift Prediction Workshop:** Numerical prediction capability for swept, medium/high-aspect ratio wings in landing/take-off (high-lift) configurations

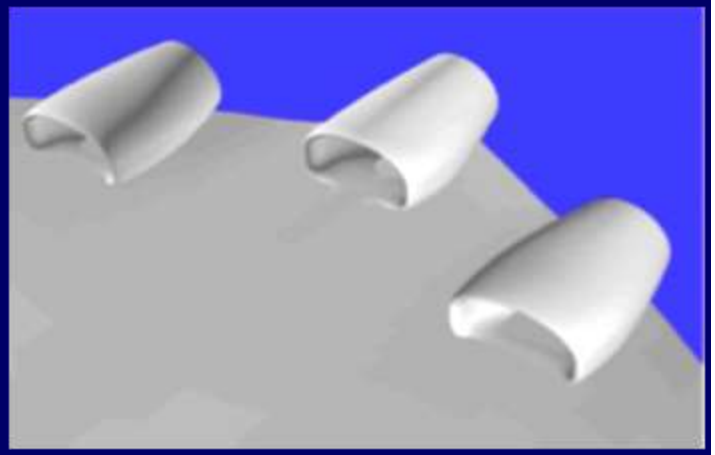
- **4th AIAA CFD Drag Prediction Workshop:** Compare predictions of forces and moments for the NASA Common Research Model (wing-body-horizontal tail) including trim drag and drag rise

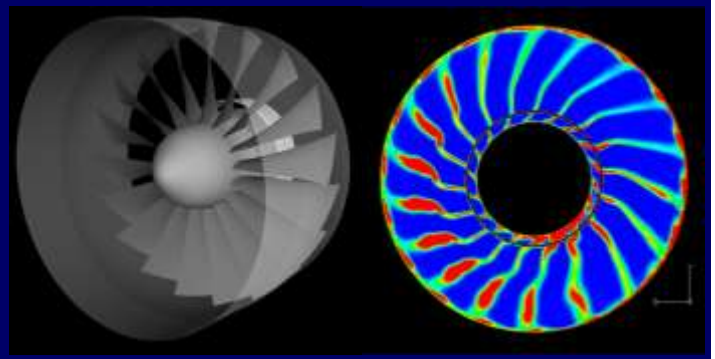




# Embedded Engines Research

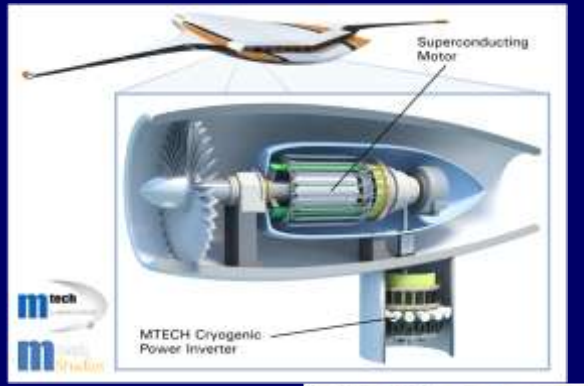
- Embedded BLI engines increase propulsive efficiency, and reduce aircraft drag, weight, and noise
- Engine technology development needed to accommodate severely distorted inlet airflow
- 3-5% fuel burn reduction possible versus advanced podded engines
- Larger benefits (>10%) possible with significantly increased BLI

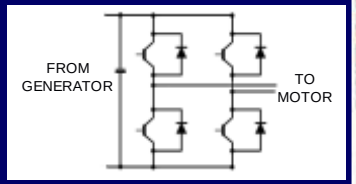




# Light and Efficient Cryogenic Converters

- Enabler of Turbo Electric Distributed Propulsion Systems
- Inverters supply power to drive the fan motors at variable speed and provide system stability
- Higher Efficiency than goal: 99.5%
- Specific Power Higher than 15 hp/lb
- Materials improvements promise further gains (e.g. composite frames for further mass reduction)




cryo inverter

# Summary

- Addressing the Environmental and Energy Efficiency Challenges
- Undertaking and Solving the Enduring and Pervasive Challenges
- Understanding and Assessing the Game Changers for the Future
- Strong Foundational Research in partnership with Industry, Academia and Other Government Agencies