ARMD Fundamental Aeronautics Program

Green Aviation Summit
Fundamental Aeronautics Program
NASA Ames Research Center
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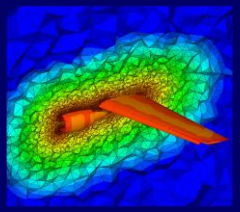
Jay Dryer
Program Director
Fundamental Aeronautics Program
Aeronautics Research Mission Directorate

Dr. Rubén Del Rosario
Principal Investigator
Subsonic Fixed Wing Project
Fundamental Aeronautics Program
Aeronautics Research Mission Directorate

ARMD Programs

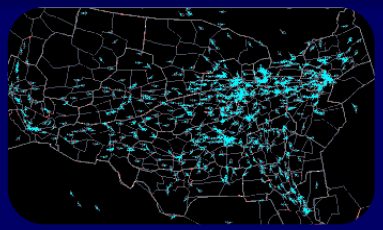
Vehicle



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.

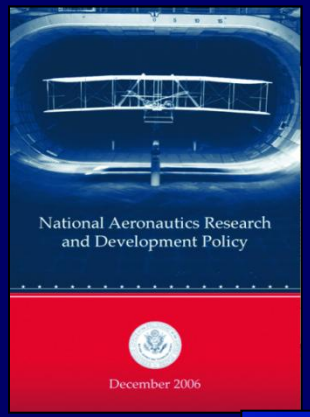
Program Organization

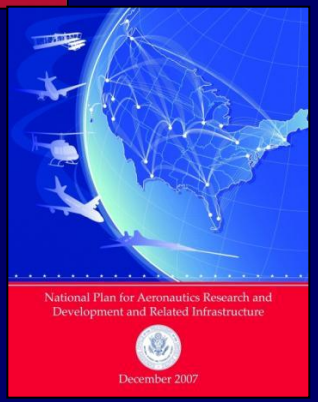
Supersonics: Eliminate environmental and performance barriers to practical supersonic transportation (sonic boom and airport noise, emissions, cruise efficiency).

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…"



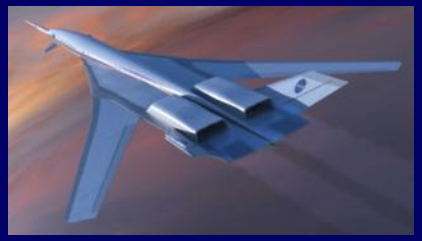


Energy and Environmental Challenges

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.



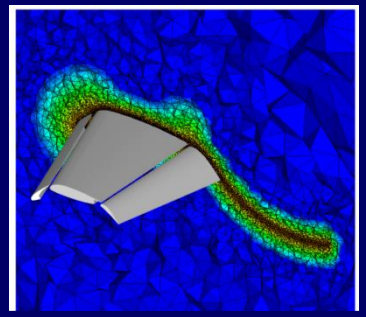
Wide Range of Research

Support to System Development

Experimental Vehicles

Novel Technologies and Materials

Experimental Data

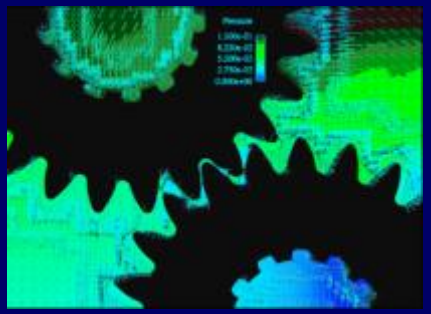


Foundational Research

Future Concepts

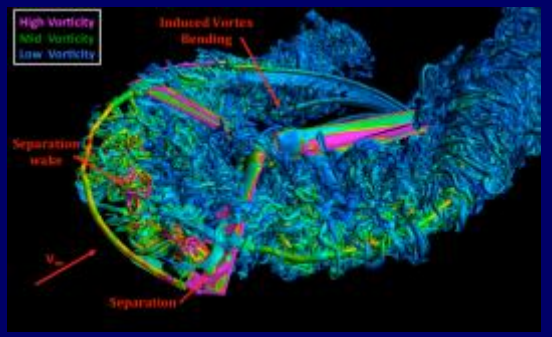
Publications and Databases

Rotorcraft Environmental Challenges



Integrated Aeromechanics/Propulsion System:

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



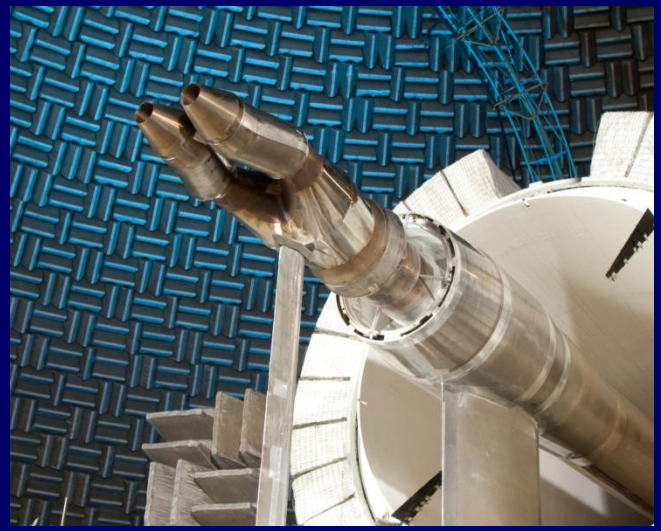
Actively-Controlled, Efficient Rotorcraft:

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

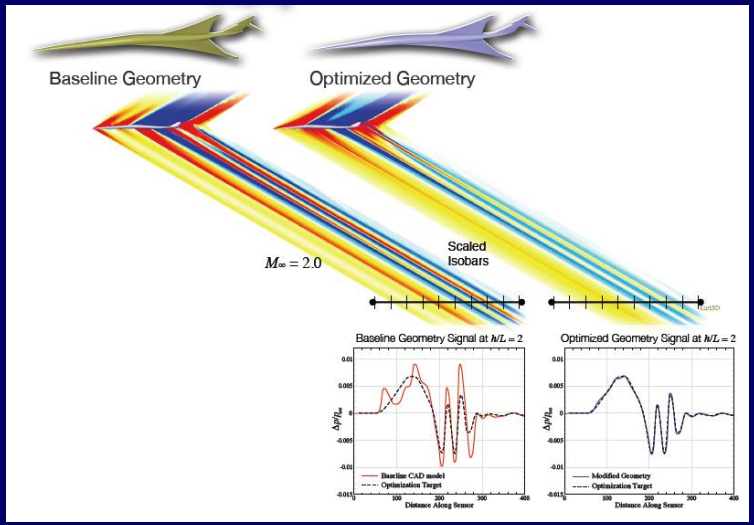
Supersonics Envrironmental Challenges

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

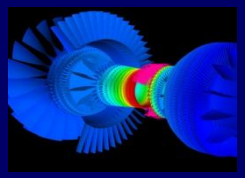


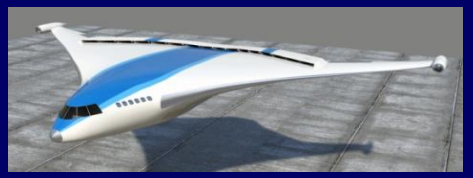
Subsonic Fixed Wing

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





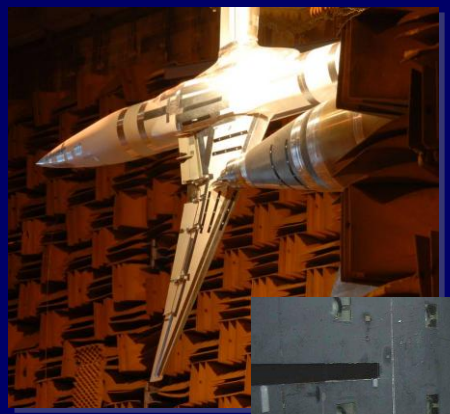
Technologies, Tools and Knowledge

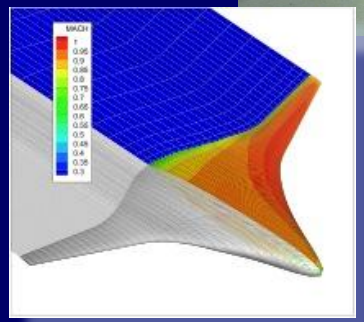
Subsonic Challenges

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.

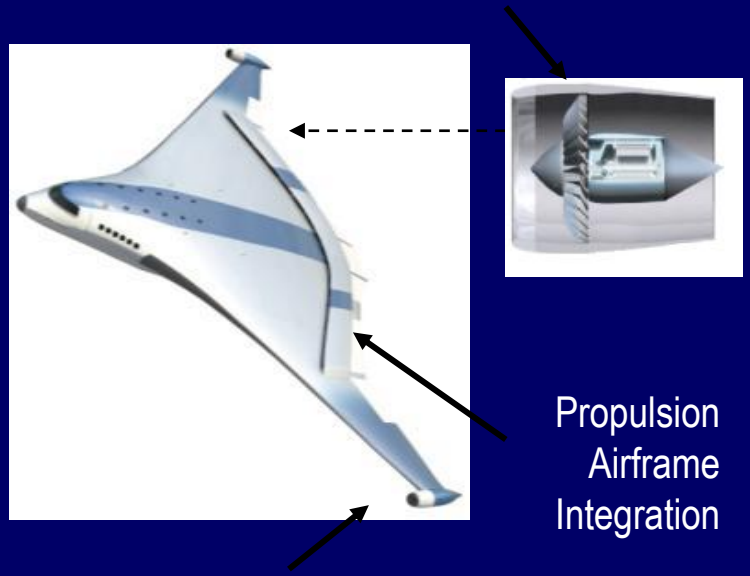
SFW N+3 Advanced Concepts Studies

- 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

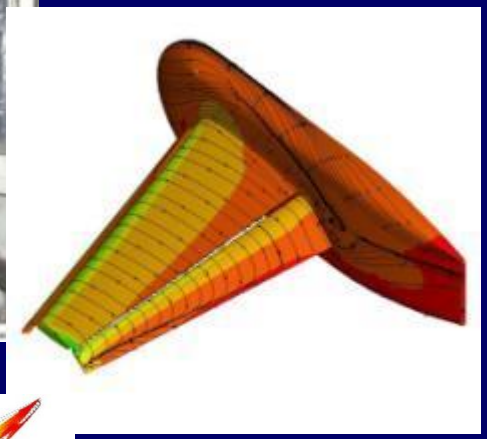
Aviation Alternative Fuel EXperiment (AAFEX)

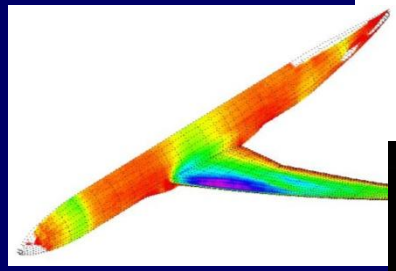
- Effect of Fischer- Tropsch Synthetic Fuels (CTL and GTL) on aircraft engine emissions plume chemistry
- F-T fuels tested at 100% synthetic and 50/50 blend with emissions sampling.
- Particulate and gaseous emissions data obtained.

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

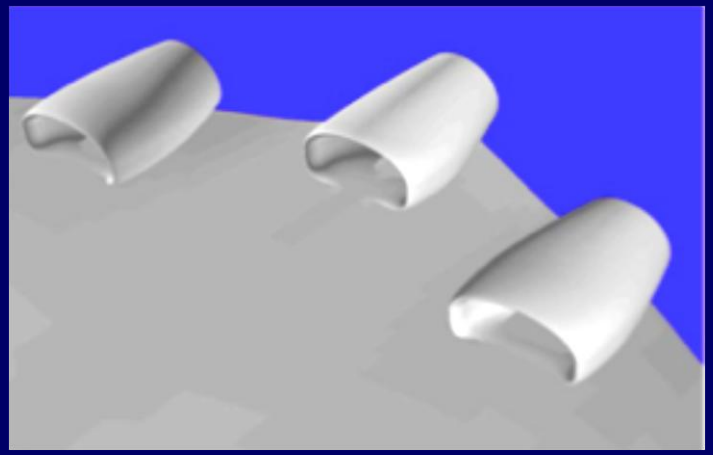
- **4th AIAA CFD Drag Prediction Workshop:** Compare predictions of forces and moments for the NASA Common Research Model (wing-body-horizontal tail) including trim drag and drag rise

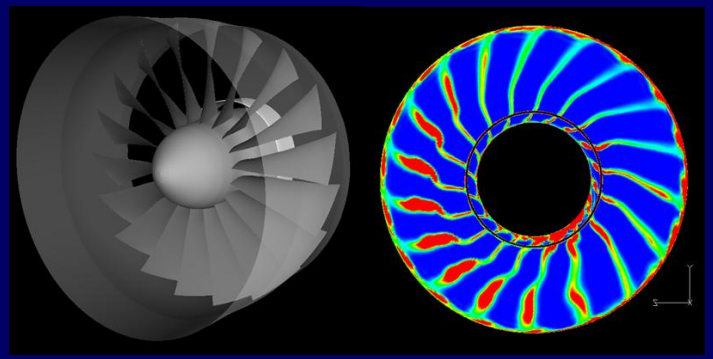




Embedded Engines Research

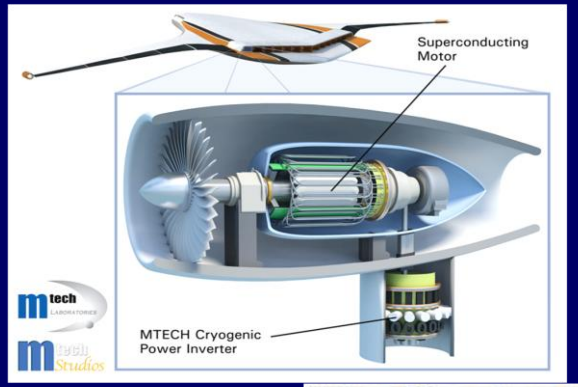
- Embedded BLI engines increase propulsive efficiency, and reduce aircraft drag, weight, and noise
- Engine technology development needed to accommodate severely distorted inlet airflow
- 3-5% fuel burn reduction possible versus advanced podded engines
- Larger benefits (>10%) possible with significantly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

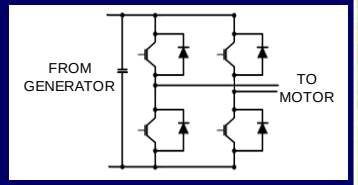




Light and Efficient Cryogenic Converters

- 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