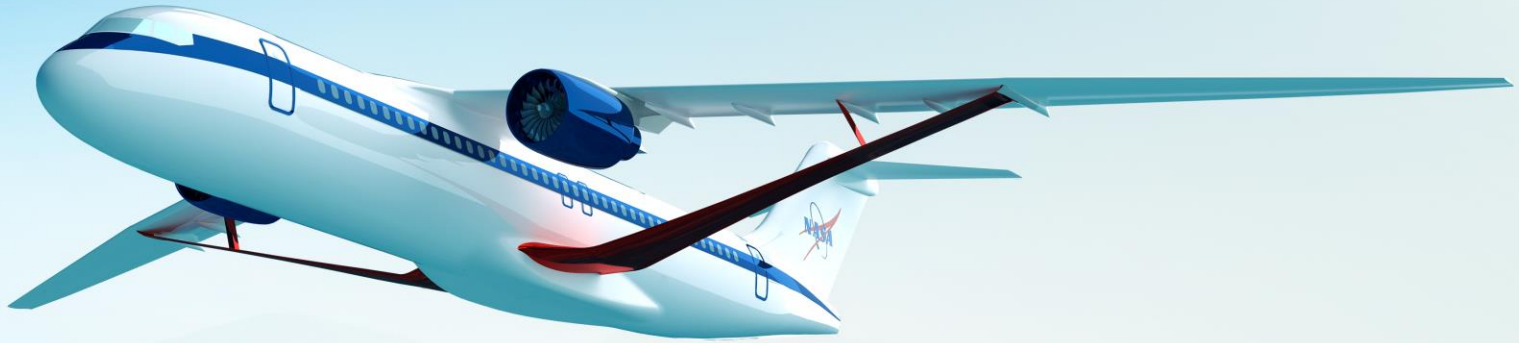

NASA Research on Advancing Sustainable Aviation and Lowering NOx Emissions

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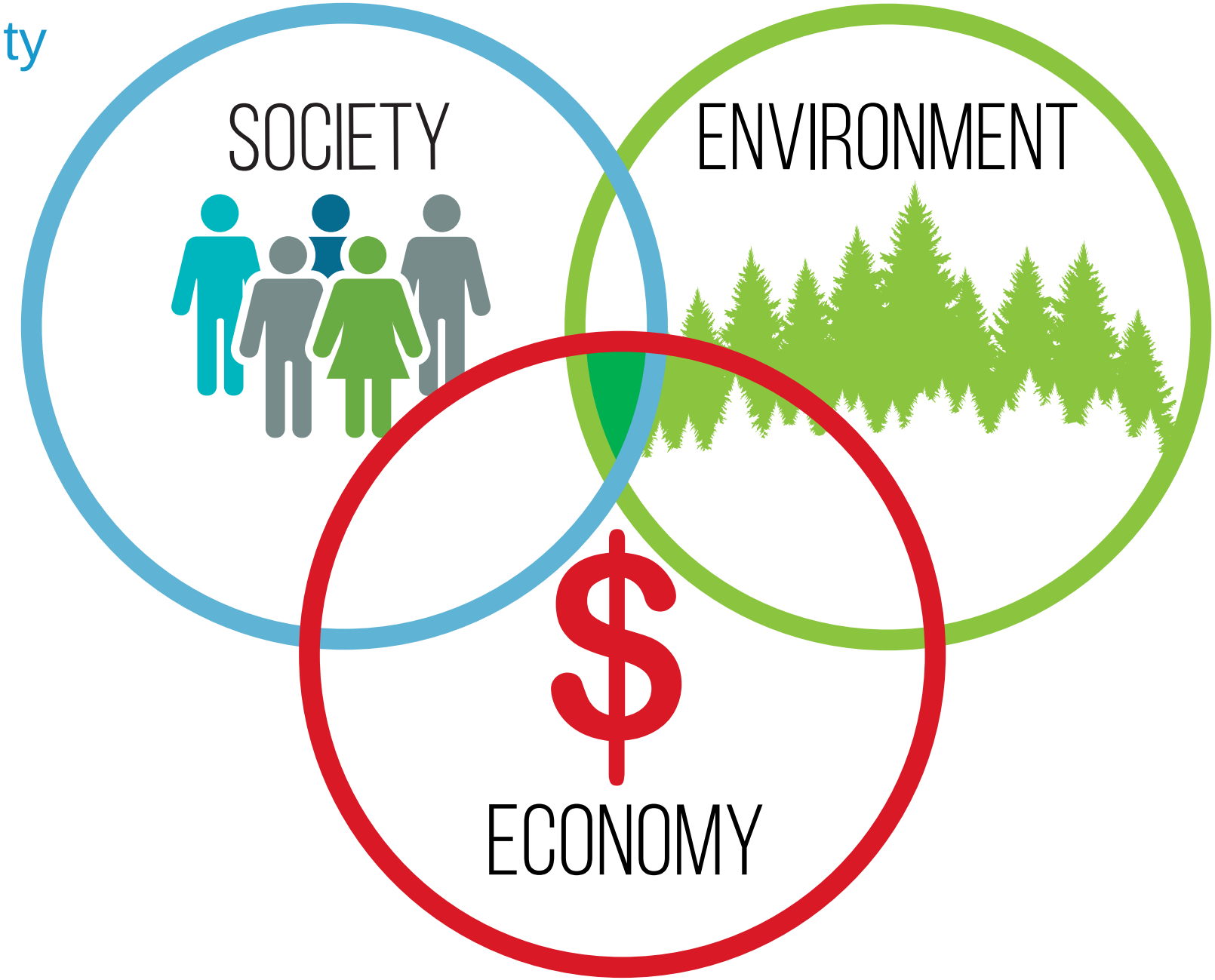
Chief, Engine Combustion, NASA Glenn Research Center

March 14, 2025

Sustainability











Four Transformations for Sustainability, Greater Mobility, and Economic Growth

Multiple Approaches to Reducing Aircraft NOx Emissions

Reducing the Fuel Burned → Engine Technologies; Airframe Technologies; Flight Operations

Reducing the NOx generated during fuel burn → Combustor Technologies

Reducing emissions is part of NASA Sustainable Aviation Efforts

Sustainable Flight National Partnership (SFNP)

Accelerating Toward Revolutionary Efficiency and Economic Impact in the 2030s

Advance engine efficiency and emission reduction

Enable integrated trajectory optimization



Advance airframe efficiency and manufacturing rate

Enable use of expanded fuel options

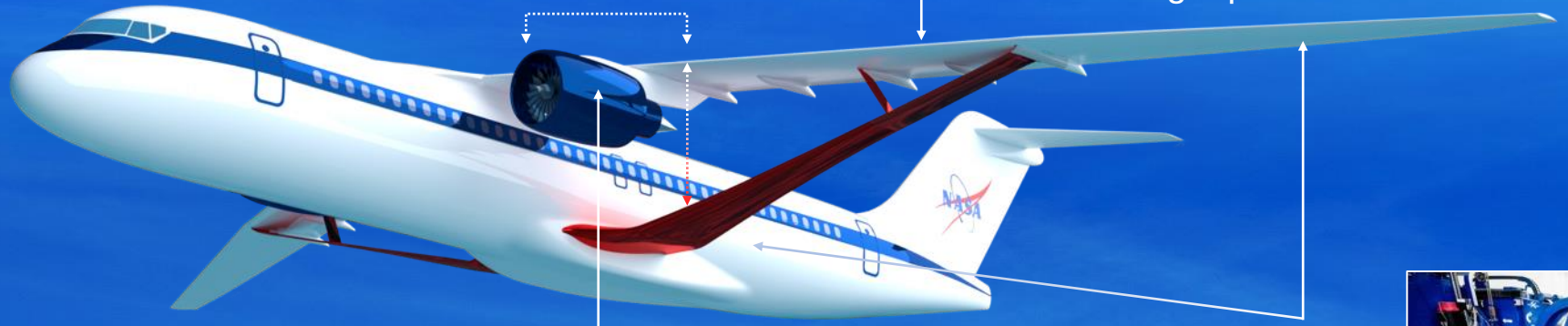
Globally competitive next-generation airliners using up to 30% less fuel, current/future fleets flying optimal trajectories with reliable, affordable fuel options

Ultra-Efficient Airliner Technologies – SFNP Portfolio

Ensure U.S. industry is the first to establish the new “S Curve” for the next 50 years of airliners

Integrated Aircraft System Efficiency
Propulsion Airframe Integration Opportunity

Aerodynamic Efficiency
Transonic Truss-Braced Wing
(5-10% fuel burn benefit)
X-66 First Flight planned for 2028

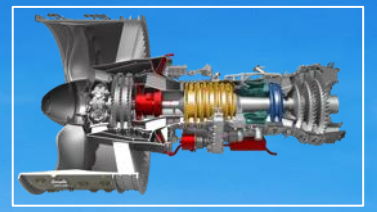




Lightweight Composites
4-6x manufacturing rate
(5-8% fuel burn benefit)
First Demo 2027



Electrified Aircraft Propulsion
(~5% fuel burn benefit)
First Flights planned in 2026



Engine Efficiency
Small Core Gas Turbine
(5-10% fuel burn benefit)
Core engine demo 2028

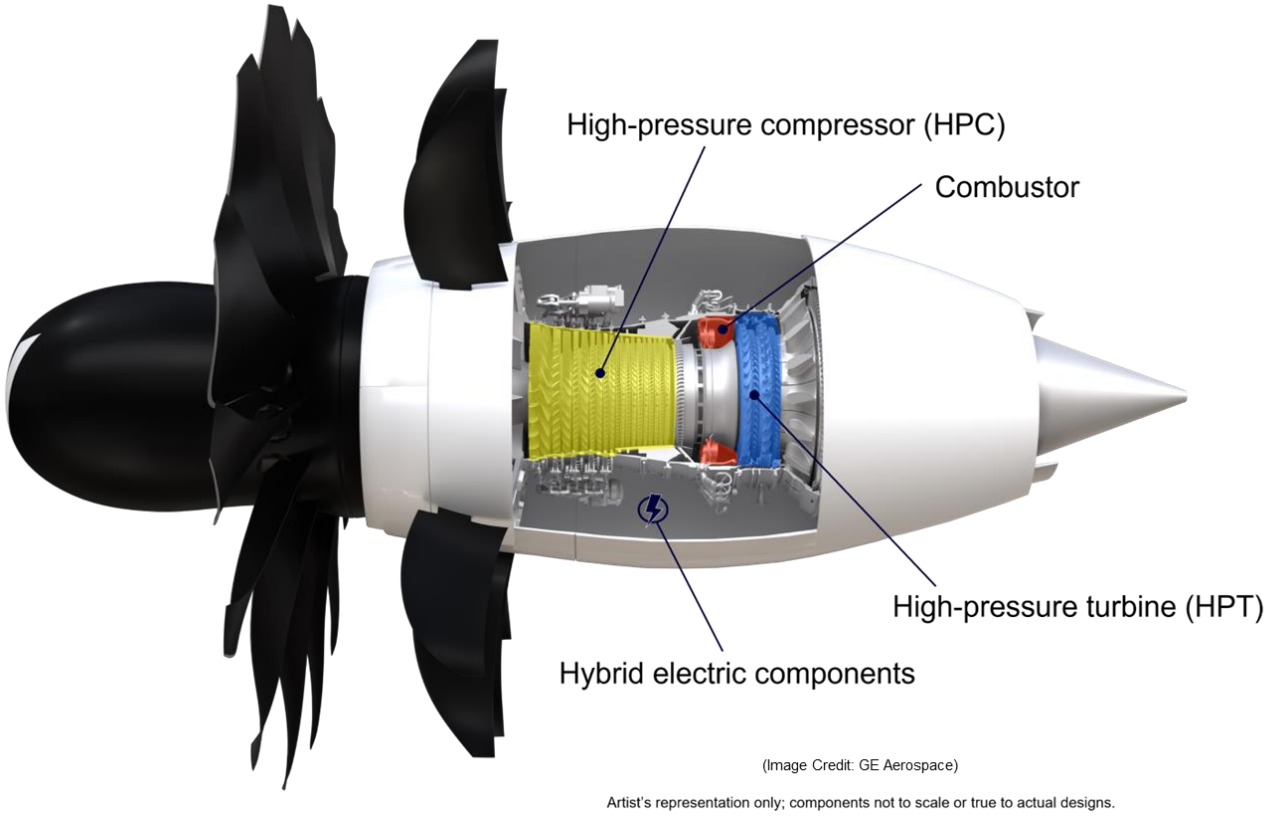
Hybrid Thermally Efficient Core Project (HyTEC)

Accelerate development and demonstration of small high-power density engine cores

Aligned with future single-aisle propulsion products

Target engine thrust of 25,000 – 35,000 lb_f

HPC Exit Corrected Flow < 3 lbm/sec



(Image Credit: GE Aerospace)

Artist's representation only; components not to scale or true to actual designs.


Turbine blade materials testing


Engine hybridization testing


High-temperature materials testing

Integrated engine core demonstration planned for 2028
Contributing 5-10% fuel burn reduction and integration of hybrid electric technology
Demonstrate operability with high blend (> 80%) sustainable aviation fuels (SAF)

Hybrid Thermally Efficient Core Project (HyTEC)

Phase I (completing in 2025) and Phase II (completing in 2028) include **combustor technology** advancements

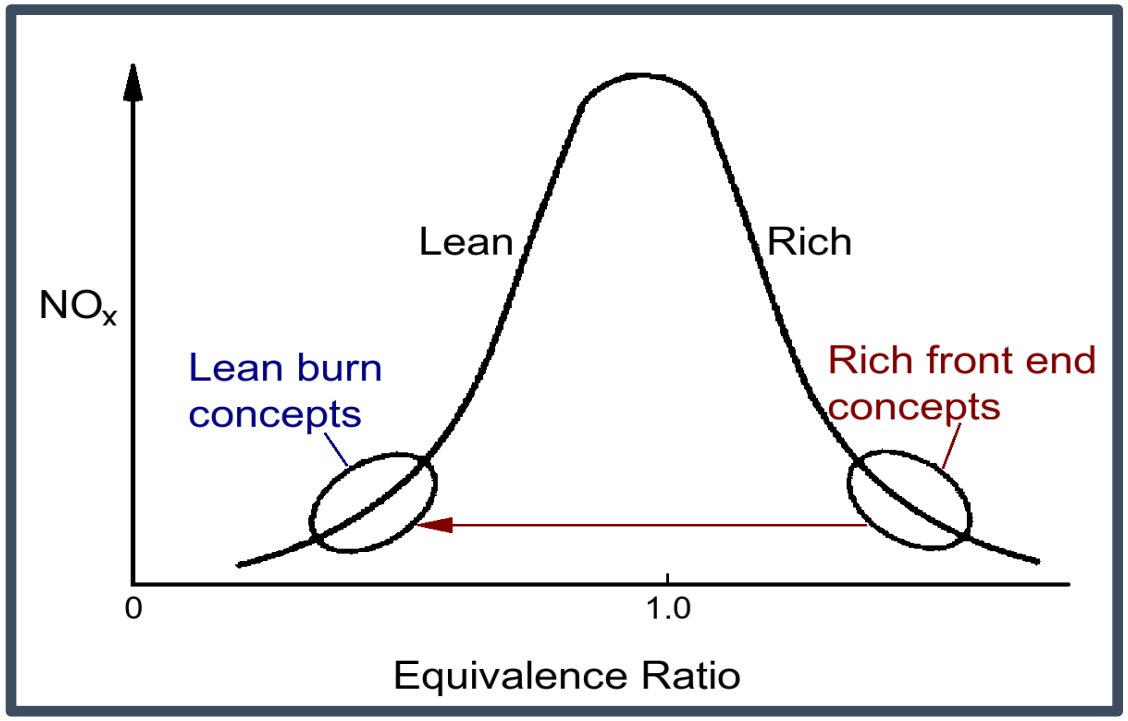
Phase 1: Pratt and Whitney Combustor Technology Contract Objectives:

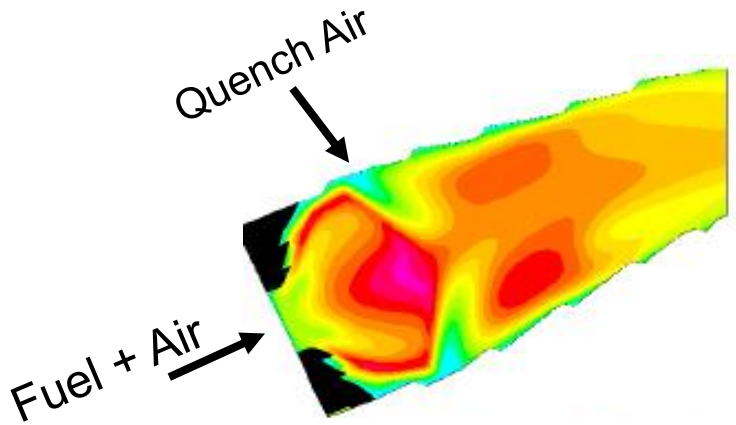
- Test two small-core combustor designs with greater than 80% blend SAF to assess operability and mature designs to TRL 4 (sector testing).
- Testing includes gaseous and particulate emissions measurements.
- Data analysis, model validation, final contract review and final reports to be completed in 2025.

Phase 2: GE Aerospace Compact Core Engine Demonstration — Combustor Technology Contract Objectives:

- Combustor is designed for small core.
- Test the engine core demonstrator (TRL 6) using both Jet-A and greater than 80% blend SAF (sustainable aviation fuel).
- Demonstrate comparable operability with high-blend SAF relative to Jet-A.

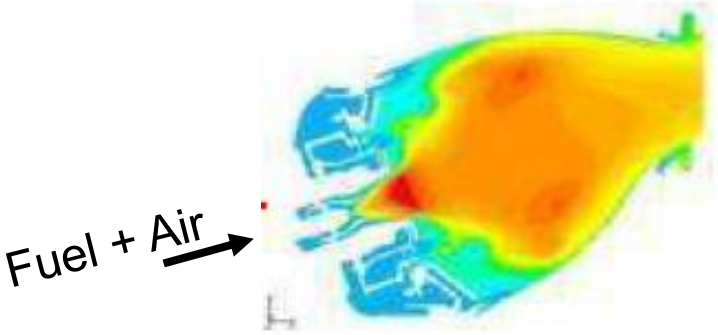
Combustor Design Approaches for Reducing NOx Emissions





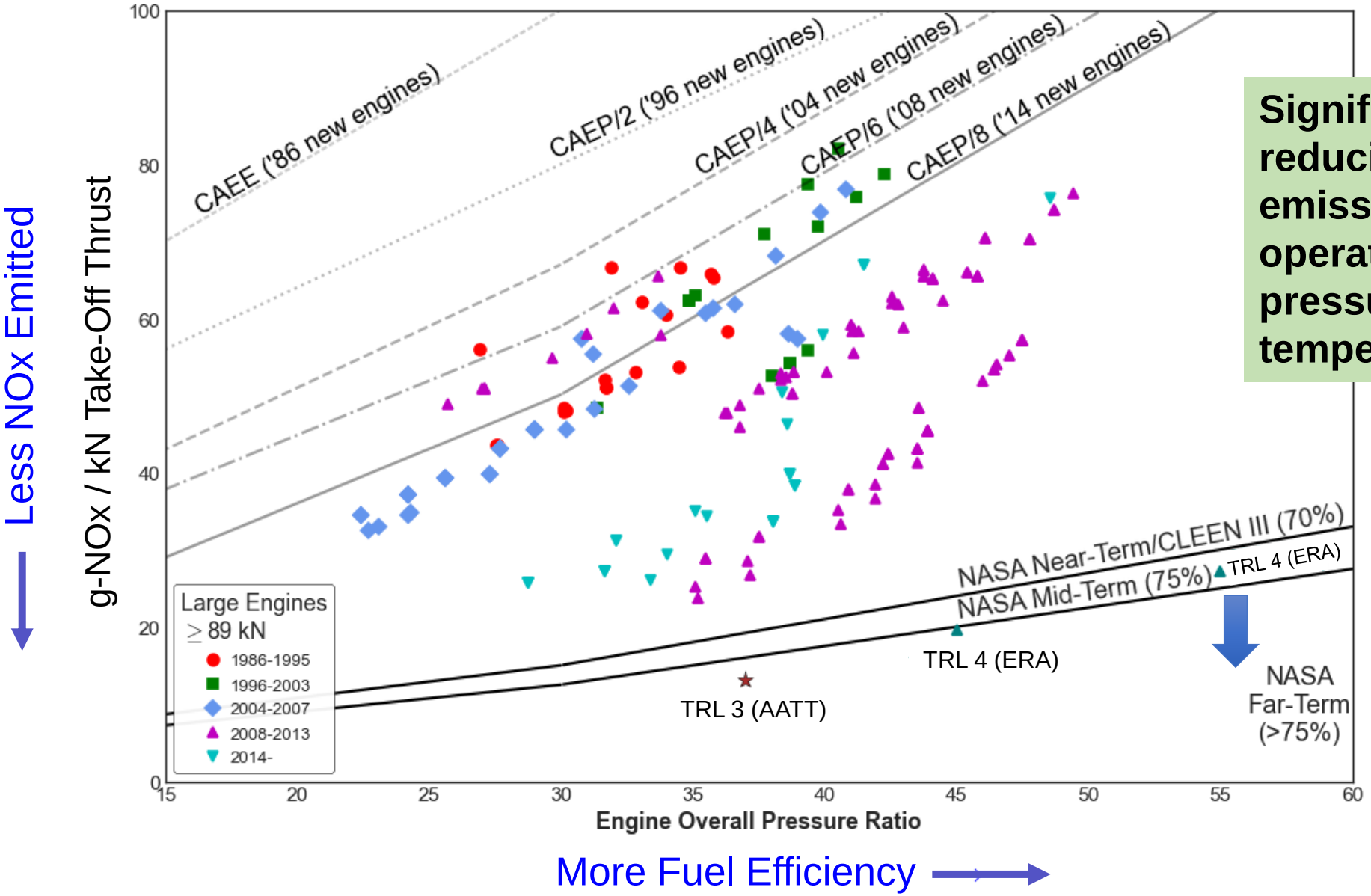
Rich Burn, Quick Quench, Lean Burn (RQL)

To reduce NOx formation, combustor designs attempt to have most of the fuel/air combustion occur under fuel rich and/or fuel lean conditions



Lean Burn (example)

Progress in Reducing Aircraft NOx Emissions

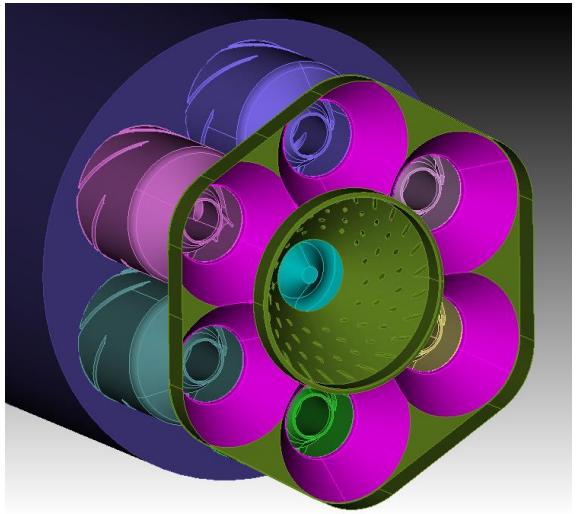


Significant progress in reducing aircraft NOx emissions as combustors operate under higher pressures and higher temperatures.

Current NASA Research on Reducing NOx Emissions

Lean-Burning Combustors

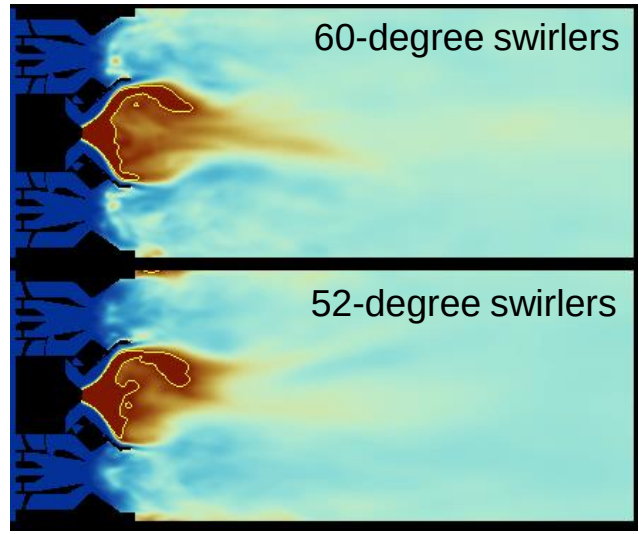
- Current focus is large reductions in cruise NOx emissions for future commercial supersonic aircraft engines (while also addressing LTO NOx)
  - Performing in-house designs, modeling and testing of low-NOx injectors
  - Contract with Collins Aerospace for design/fabrication of low-NOx injector for future testing at NASA
- Future work may include impacts of fuel heating on emissions and operability. (Fuel heating may be part of future small engine core subsonic aircraft and/or higher speed supersonic commercial aircraft).



Lean Direct Injection
(7 injectors, axial swirlers)

Fuel Impacts

- Continue evaluation of impacts of sustainable aviation fuels (SAF) on combustor operability and emissions
  - Impact of SAF on NOx emissions is typically small (a few percent)
  - NASA is a joint partner in ground and flight tests such as recent Boeing eco-Demonstrator emissions testing with various fuel blends.



Predicted NOx contours

NOx versus Soot Emissions

- Some combustor designs may need to trade NOx reductions with increases in soot emissions. Improved understanding of soot emissions is ongoing.

Summary

NASA is leading aviation transformations addressing a range of aircraft sizes and speed regimes.

The Sustainable Flight National Partnership is driving reductions in fuel burn and emissions, which will provide real economic impact for next generation subsonic aircraft.

NASA is also addressing key barriers to commercial supersonic flight while also developing solutions to reduce emissions across the entire flight and reduce landing and take-off noise.

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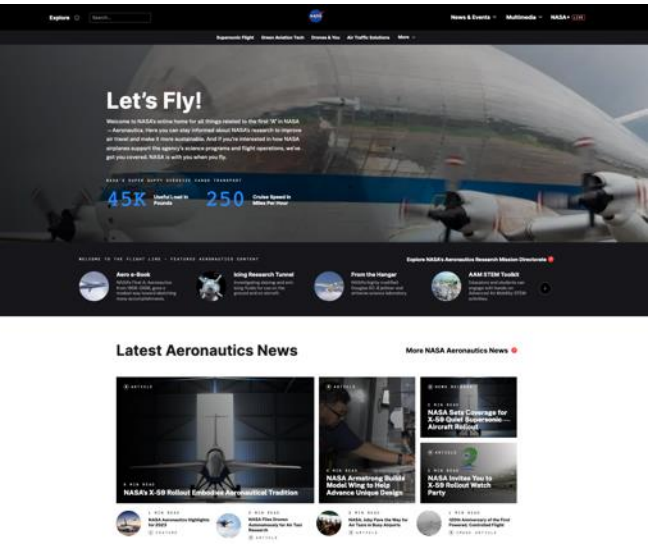

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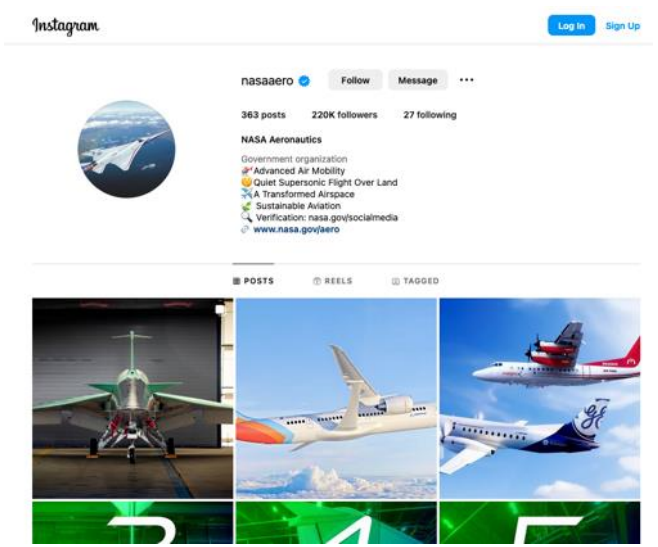

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