ICAO: UNITING AVIATION ON CLIMATE CHANGE

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ICAO Colloquium on Aviation and Climate Change

Integrated System Research Program
Environmentally Responsible Aviation (ERA) Project
A NASA Aeronautics Project focused on midterm environmental goals

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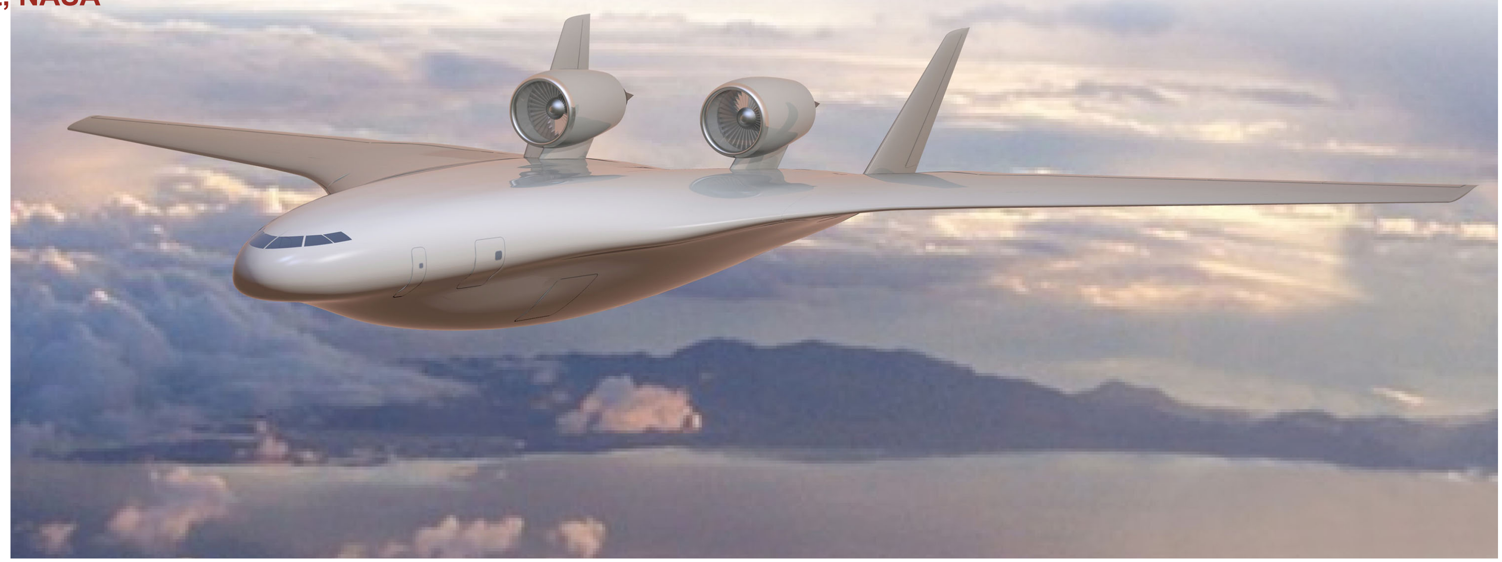


Topics Addressed

- ERA Goals, Objectives and System Level Metrics
- ERA Project Flow and FY11 President's Budget
- "Technology Collectors" – Current Set
- Technical Approach - Accomplishing N+2 Goals
- Concluding Remarks

ERA Goals, Objectives & System Level Metrics

Over the next 5 years:

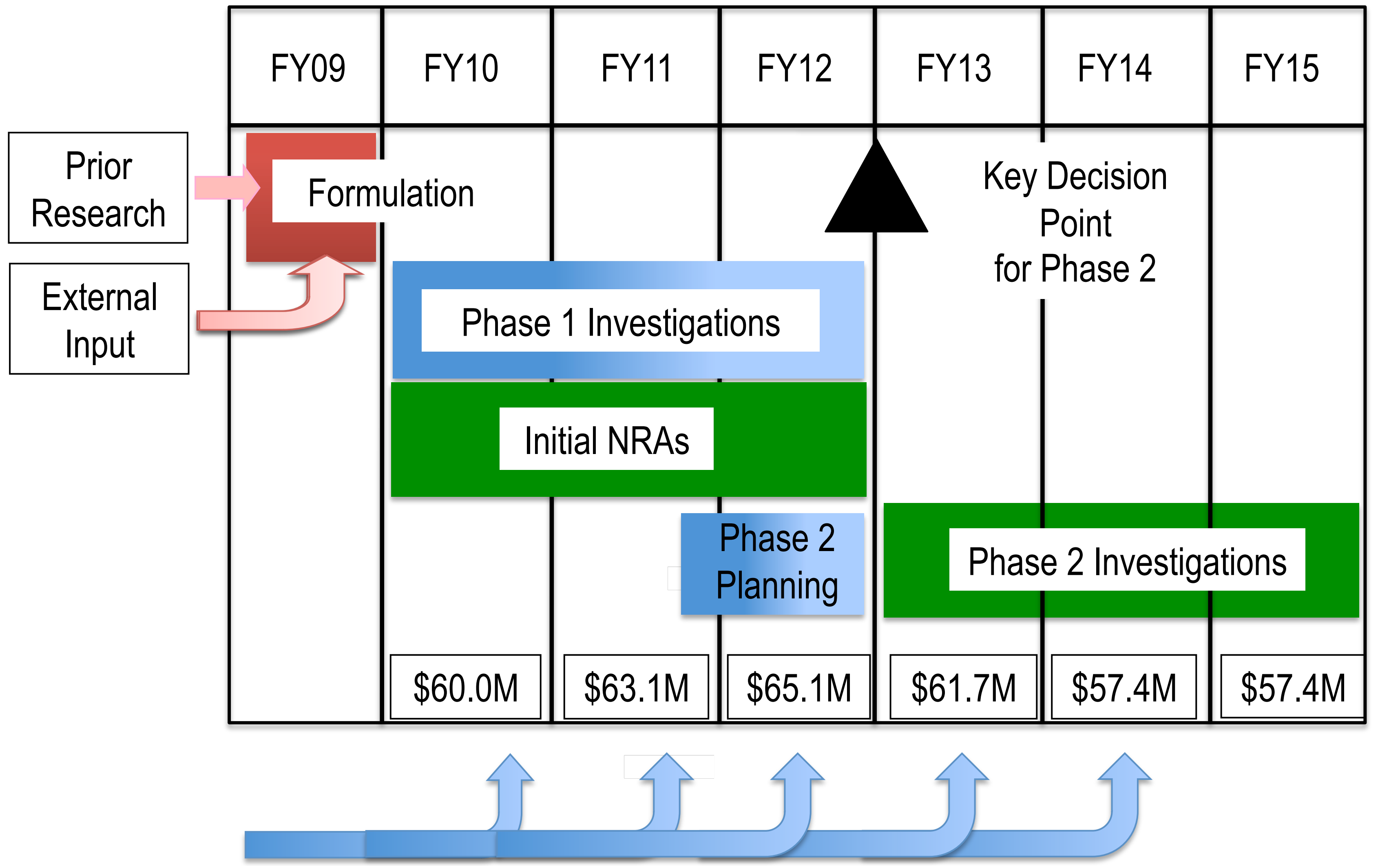
- Explore and mature alternate unconventional aircraft designs and technologies that have potential to simultaneously meet community noise, fuel burn, and NOX emission N+2 goals as described in the National Aeronautics R & D Plan
- Determine potential impact of these aircraft designs and technologies if successfully implemented into the Air Transportation System
- Determine potential impact of these technologies on advanced N+2 “tube and wing” designs

CORNERS OF THE TRADE SPACE	N+1 = 2015*** Technology Benefits Relative To a Single Aisle Reference Configuration	N+2 = 2020*** Technology Benefits Relative To a Large Twin Aisle Reference Configuration	N+3 = 2025*** Technology Benefits
Noise (cum below Stage 4)	-32 dB	-42 dB	-71 dB
LTO NO_x Emissions (below CAEP 6)	-60%	-75%	better than -75%
Performance: Aircraft Fuel Burn	-33%	-50%**	better than -70%
Performance: Field Length	-33%	-50%	exploit metro-plex* concepts

*** Technology Readiness Level for key technologies = 4-6. ERA will undertake a time phased approach, TRL 6 by 2015 for “long-pole” technologies
** RECENTLY UPDATED. Additional gains may be possible through operational improvements
* Concepts that enable optimal use of runways at multiple airports within the metropolitan area

ERA Project Overview, Flow

And Key Decision Point for Phase 2

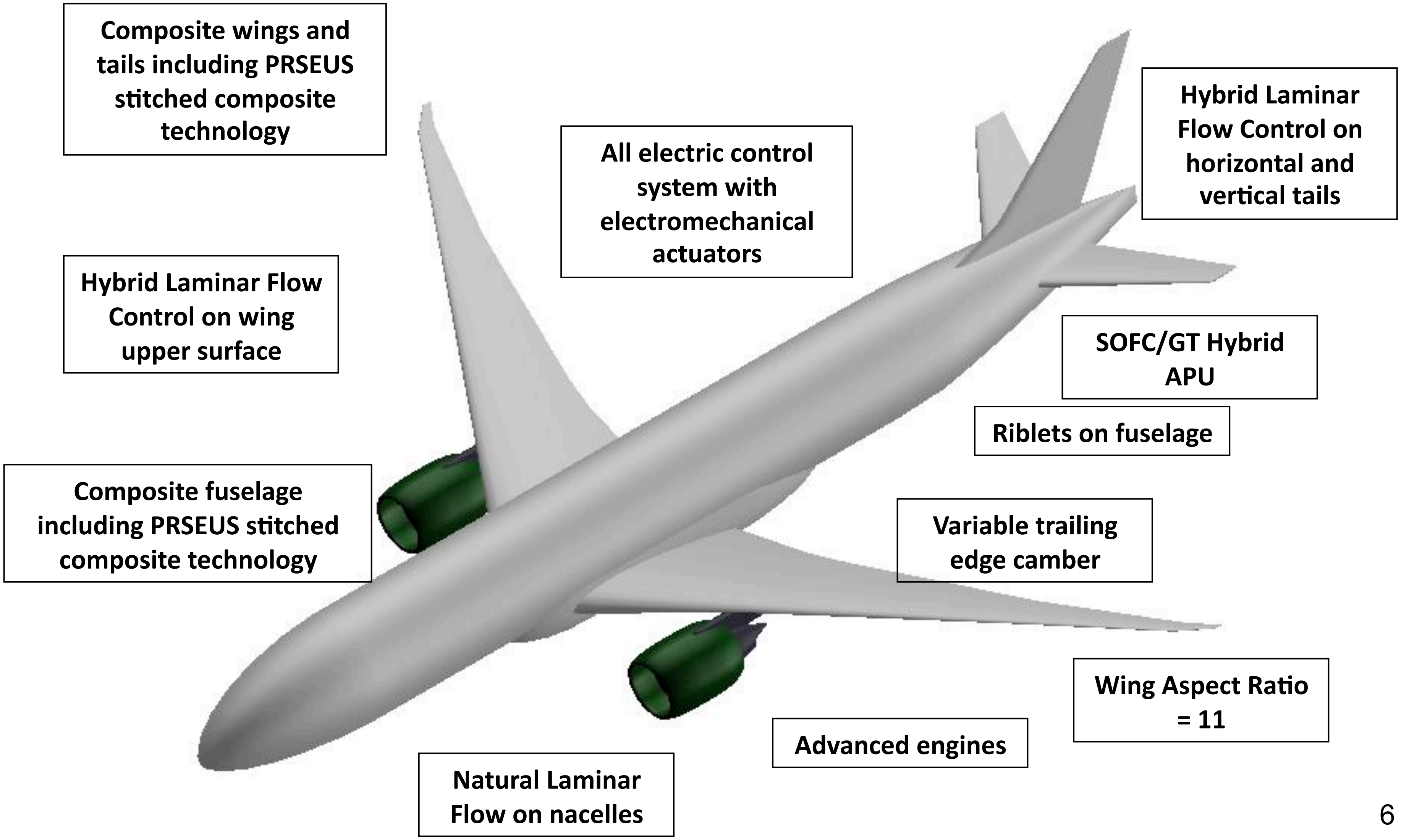


Technical input from Fundamental Programs, NRAs, Industry, Academia, Other Gov't Agencies

Technology "Collectors"

Advanced Configuration 1

N+2 Advanced “tube-and-wing“ 2025 Timeframe



Advanced Configuration 2A

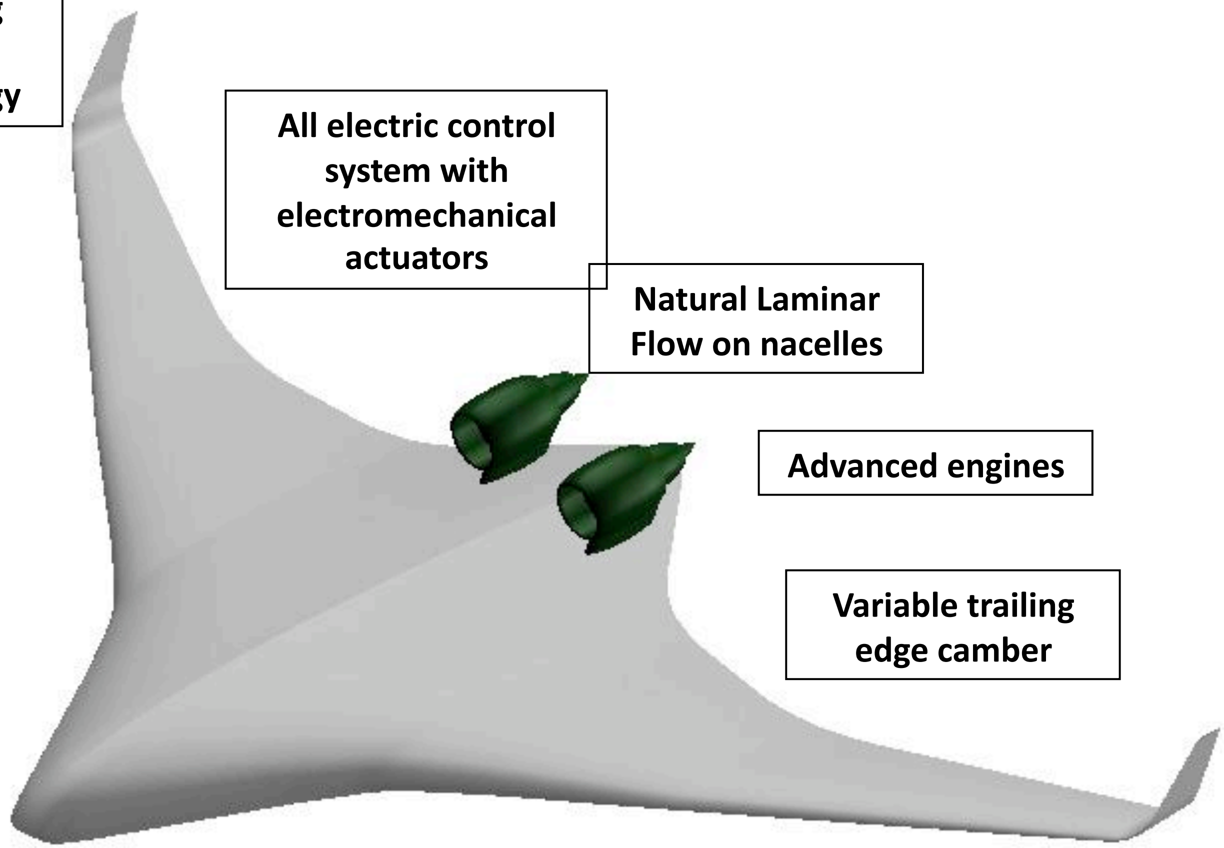
N+2 Advanced HWB300 2025 Timeframe

Composite centerbody and wings including PRSEUS stitched composite technology

All electric control system with electromechanical actuators

Hybrid Laminar Flow Control on outer wing sections

Natural Laminar Flow on nacelles



Advanced engines

Riblets on centerbody

Variable trailing edge camber

SOFC/GT Hybrid APU

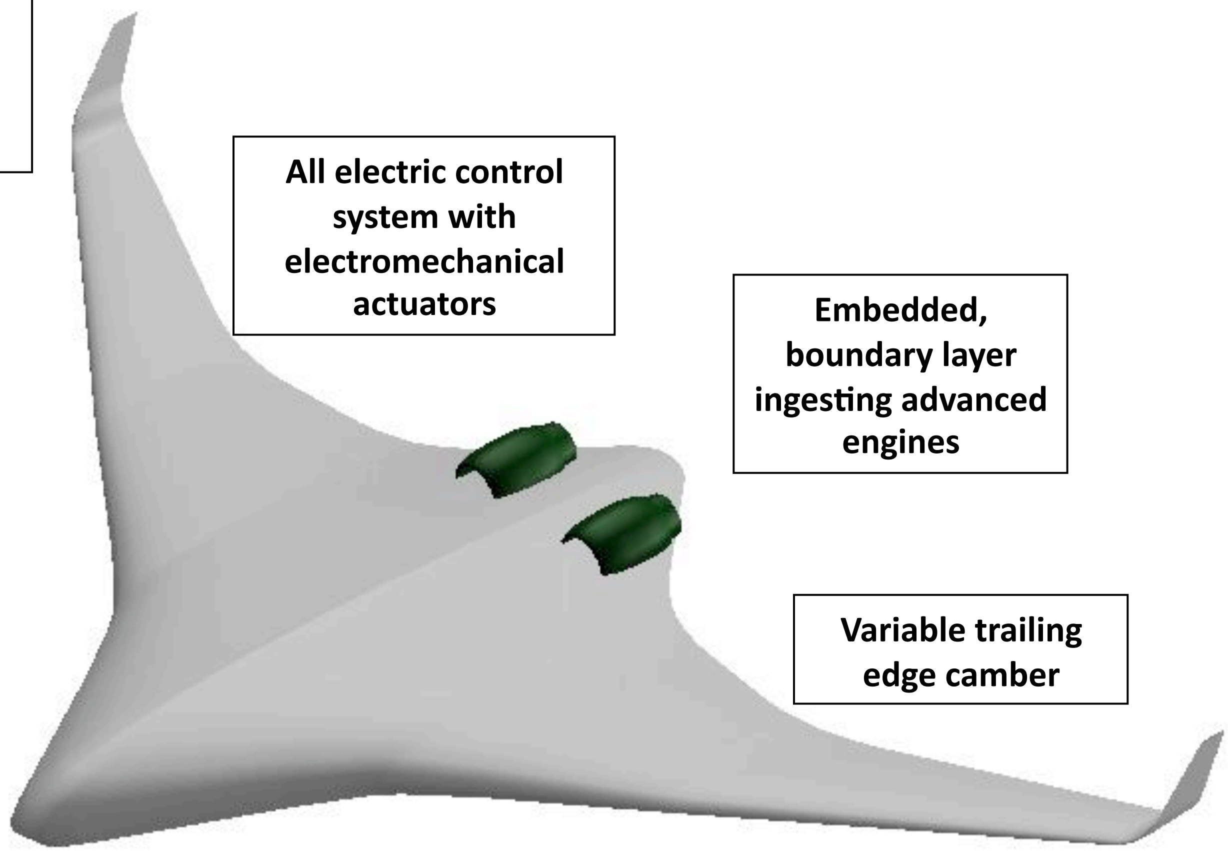
Advanced Configuration 2B
N+2 HWB300 2025+ Timeframe

Composite centerbody and wings including PRSEUS stitched composite technology

All electric control system with electromechanical actuators

Hybrid Laminar Flow Control on outer wing sections

Embedded, boundary layer ingesting advanced engines



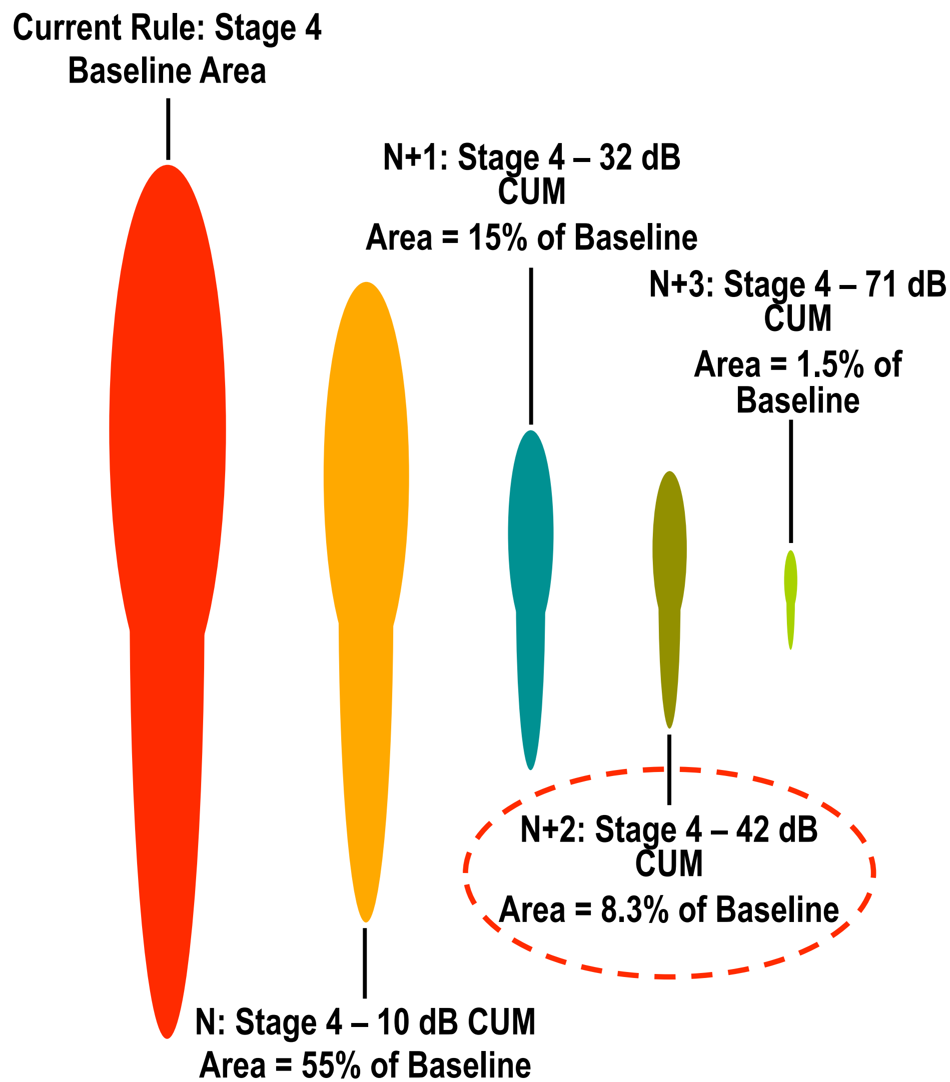
Laminar flow control on centerbody

Variable trailing edge camber

SOFC/GT Hybrid APU

Specific System Level Metrics and Technical Approaches

NASA's Noise Reduction Goals

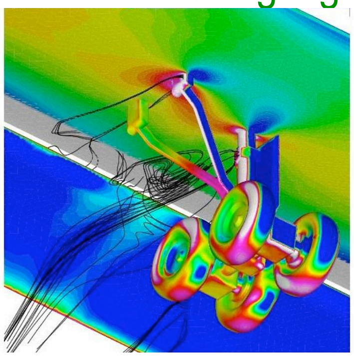


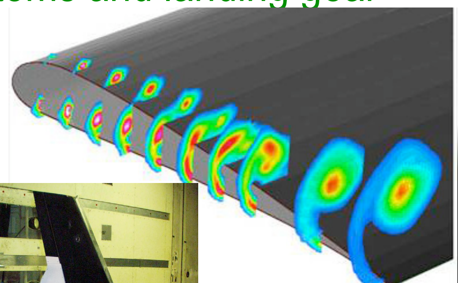
- Relative ground contour areas for notional Stage 4 and N+1, N+2, and N+3 aircraft
  - Independent of aircraft type/weight
  - Independent of baseline noise level
- Noise reduction assumed to be evenly distributed between the three certification points
- Simplified model: Effects of source directivity, wind, etc. not included

Addressing Noise Reduction

Airframe Noise

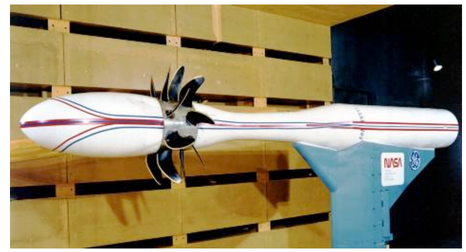
Addressing high-lift systems and landing gear





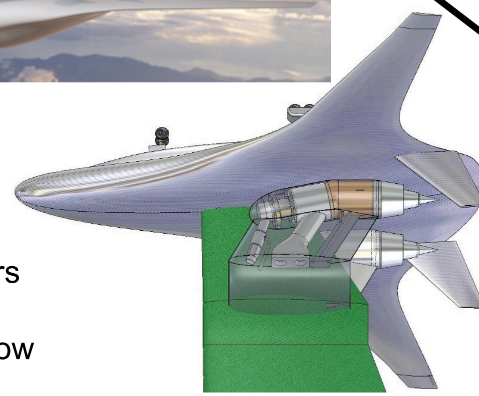
Propulsion Noise

Addressing fan, core, and jet noise



Open Rotor

UHB Turbofans



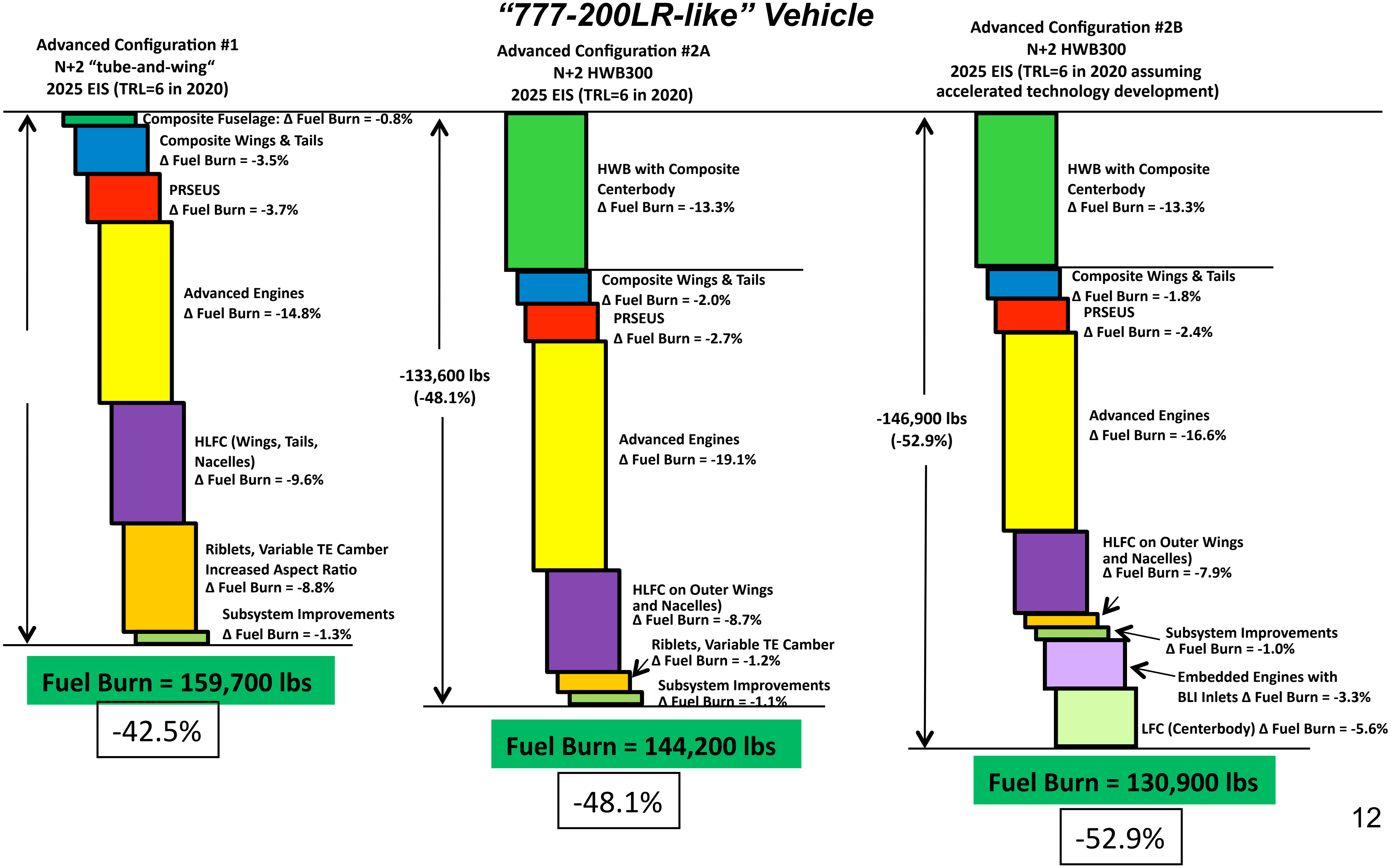
- Twin High Bypass Ratio Jet Simulators
- Simplified Fan Noise Simulator
- Instrumentation and Processing for Low Noise Levels

Propulsion Airframe Aeroacoustics

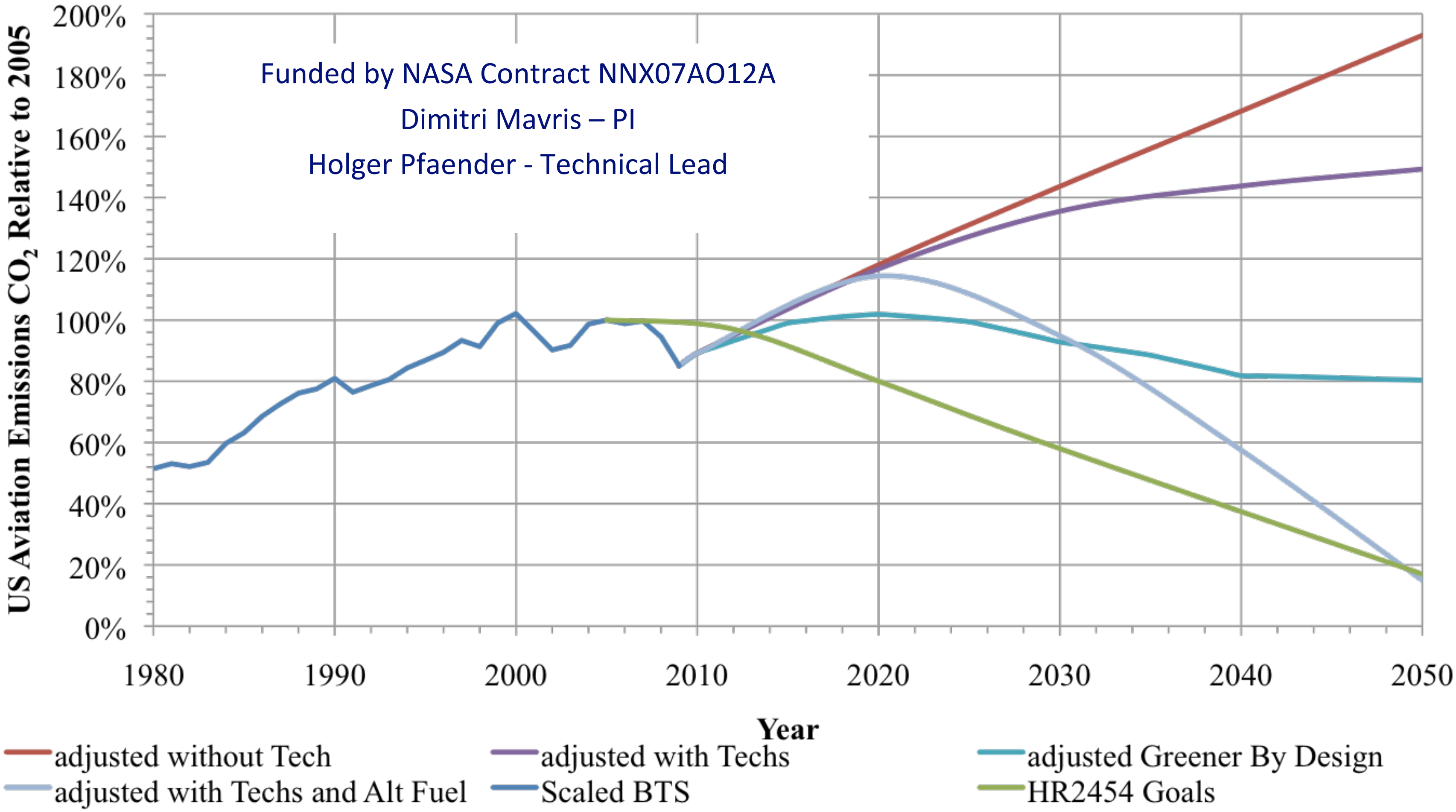
Addressing airframe/propulsion interaction - shielding

N+2 Fuel Burn (and CO_2) Reduction Goal

Reference Fuel Burn = 277,800 lbs
"777-200LR-like" Vehicle



NASA Fuel Burned Goals – More Insight



Magnitude of emissions growth and gap is dependent upon aviation traffic growth assumptions

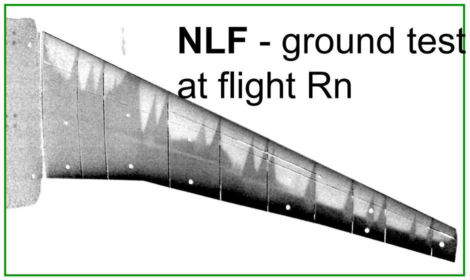
Addressing Fuel Burn (CO_2 Emissions)

DRAG REDUCTION via Laminar Flow

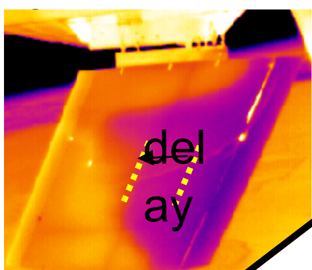
Addressing concepts & barriers
to achieving practical laminar flow on transport a/c

HLFC - revisit crossflow expt
- understand system weight

NLF - ground test at flight Rn



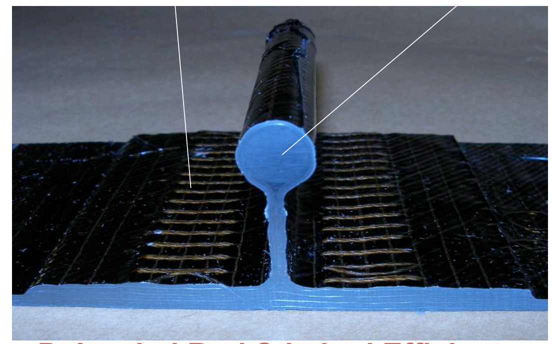
DRE - exploring the limits with respect to Rn



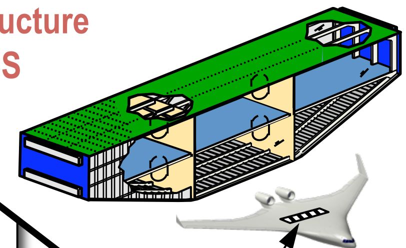
WEIGHT REDUCTION via Advanced Structures

Moving from “safe-life” to “fail-safe” design
with a lightweight composite structure

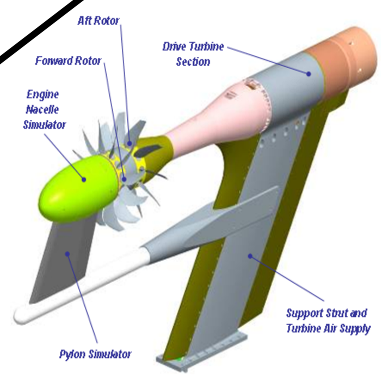
Stitches
Rod



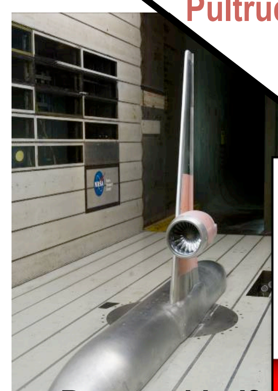
Pultruded Rod Stitched Efficient Unitized Structure
PRSEUS



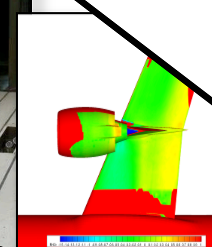
Test Region



Open Rotor Propulsion Rig



Powered half-span model test

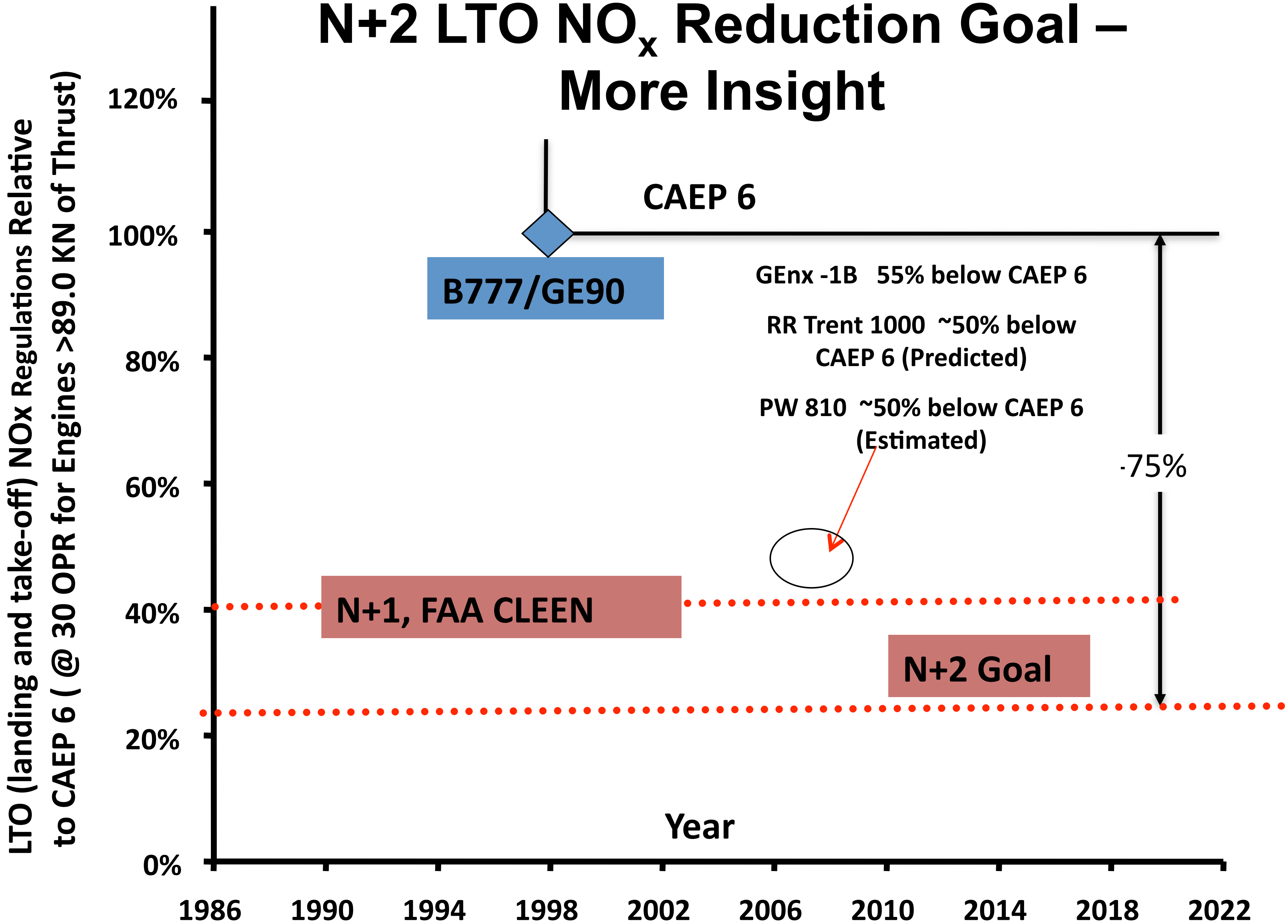


PSP Results

SFC REDUCTION via UHB

Addressing multidisciplinary challenges from subcomponent to installation
to achieve ultra-high by-pass ratio

N+2 LTO NO_x Reduction Goal – More Insight

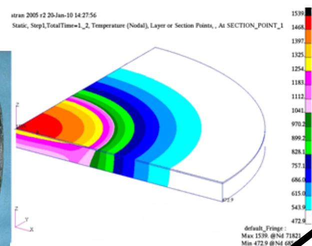


Addressing Reduced LTO NO_x Emissions

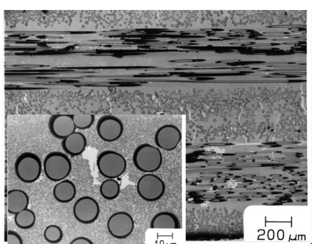
ERA CMC Combustor Liner

CMC combustor liner enables new engine designs incorporating higher engine temperatures and reduced cooling air flows

CMC combustor liner

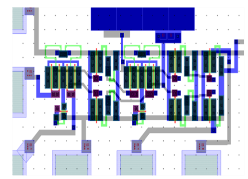


SIC CMC – enable higher temperature engine



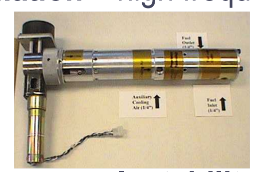
Active Combustion Instability Control

Demonstrating the capability to suppress combustor instabilities for low emission combustors

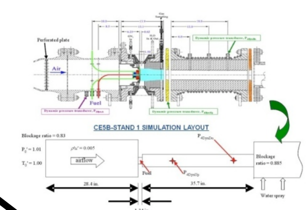


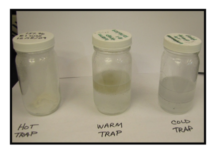
High Temperature SiC electronics circuits and dynamic pressure sensors

Fuel Modulation – high frequency fuel delivery systems

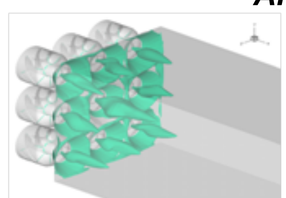


Instability Models and Control Methods





Alternative fuel



Innovative Injector Concept

ASCR Combustion Rig

Low Nox, Fuel-Flexible Combustor

- High Bypass Ratio/High Pressure Combustor
- Superior Alternative Fuel properties
- Enhance Fuel/Air Mixing
- Advanced Ignition

Concluding Remarks

- NASA intends to release a BROAD solicitation in a month to:
  - Seek up to 4 subsonic transport vehicle concepts capable of simultaneous achievement of the N+2 noise, NOX and fuel burn system level metrics
  - Develop 15-year technology maturation roadmaps – addressing propulsion and airframe and integration requirements
  - Determine initial system readiness levels, and plot expected system readiness maturation with execution of the 15-year technology roadmaps
  - Explore two additional options -
    - Option 1 – Select up to 2 of subsonic transport vehicle concepts to develop preliminary designs (of sufficient scale to demonstrate goals)
    - Option 2 – Identify risk reduction testing and assessment programs associated with the scaled vehicles.
  - Period of performance is 27 months