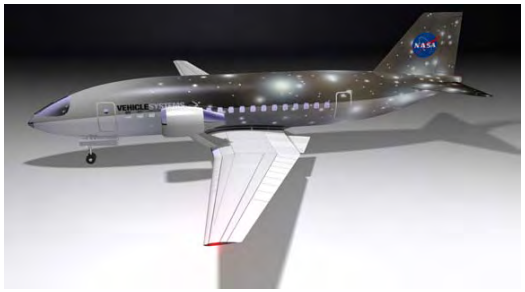
Subsonic Fixed Wing Project

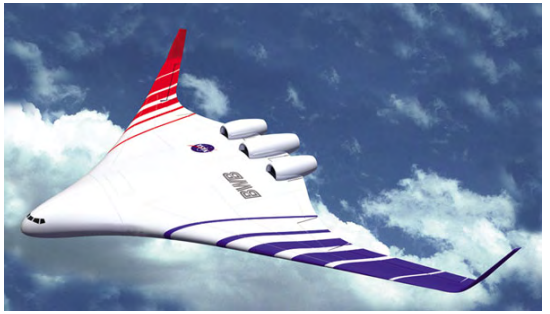
.... technology for dramatically improving noise, emissions, & performance

CORNERS OF THE TRADE SPACE	N+1 Generation Conventional Tube w/Wing (2012-2015)	N+2 Generation Unconventional Hybrid Wing Body (2018-2020)
Noise (cum below Stage 3)	- 42 dB	- 52 dB
LTO NOx Emissions (below CAEP 2)	-70%	-80%
Performance: Aircraft Fuel Burn (relative to B737/CFM56)	-33%	-50%***
Performance: Field Length (relative to B737/CFM56)	-33%	-50%

N+1 Conventional



N+2 Hybrid Wing/Body



SFW Project Overview

SFW Project Team

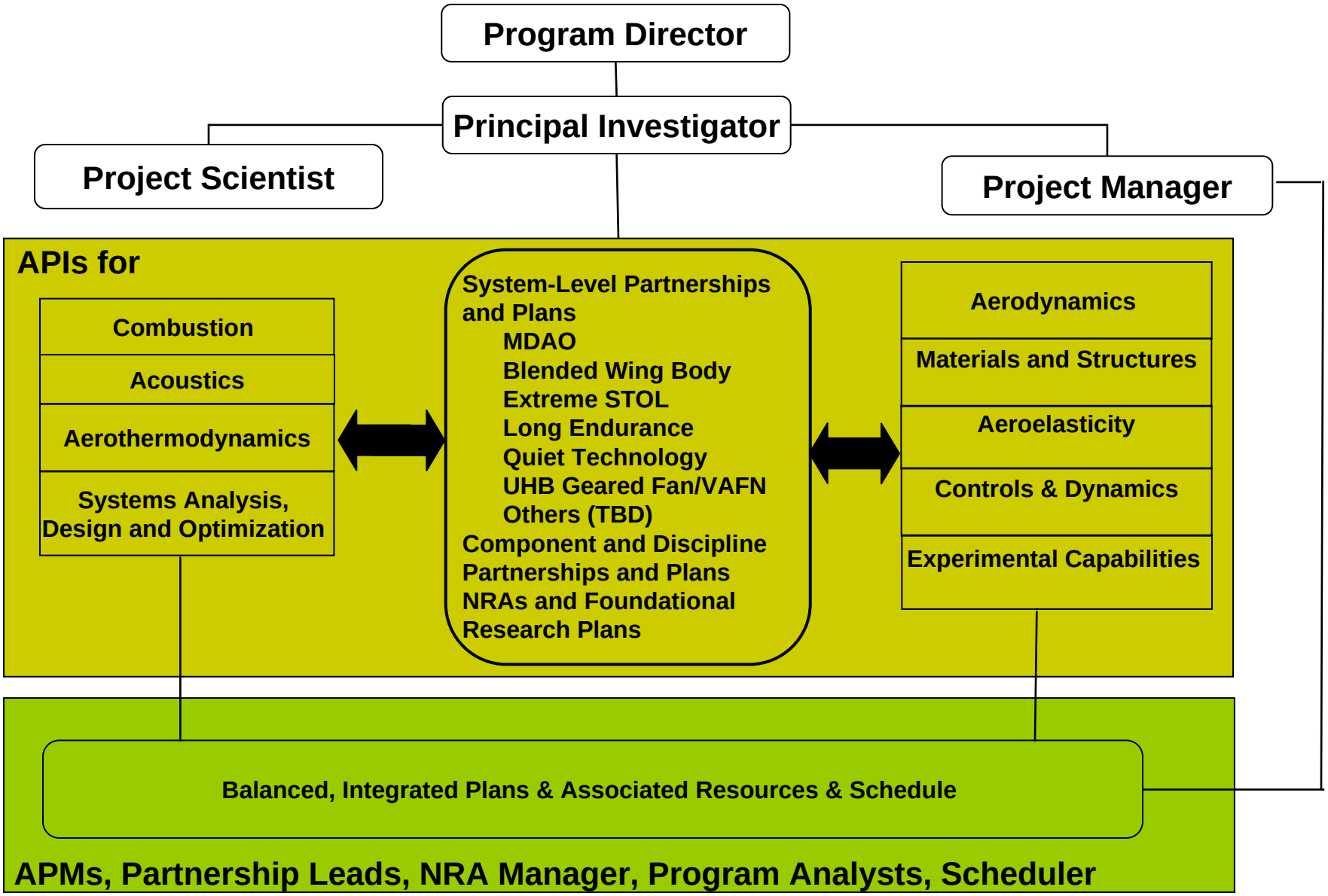
Presented by: F. S. Collier, PhD

Principal Investigator

Description of SFW Project

- *Objectives*
  - Development of prediction and analysis tools for reduced uncertainty in design process
  - Development of concepts/technologies for enabling dramatic improvements in noise, emissions and performance characteristics of subsonic/transonic aircraft
- *Relevance*
  - Direct impact on future designs of a wide range of subsonic aircraft relevant to industry, DoD, and OGA
  - Direct impact on JPDO & NGATS operational and environmental goals and objectives

Organization of SFW Project



System Level Metrics

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

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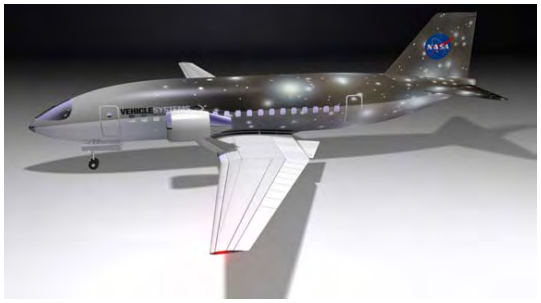
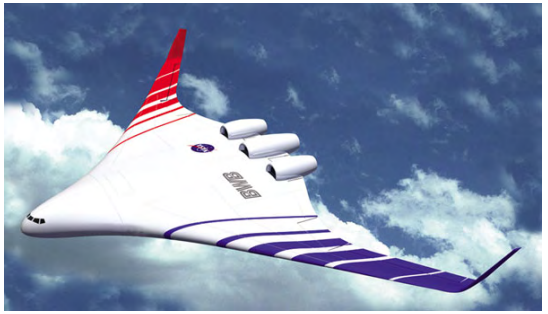


N+2 Hybrid Wing/Body



Approach

- Enable Major Changes in Engine Cycle/Airframe Configurations

- Reduce Uncertainty in Multi-Disciplinary Design and Analysis Tools and Processes

- Develop/Test/ Analyze Advanced Multi-Discipline Based Concepts and Technologies

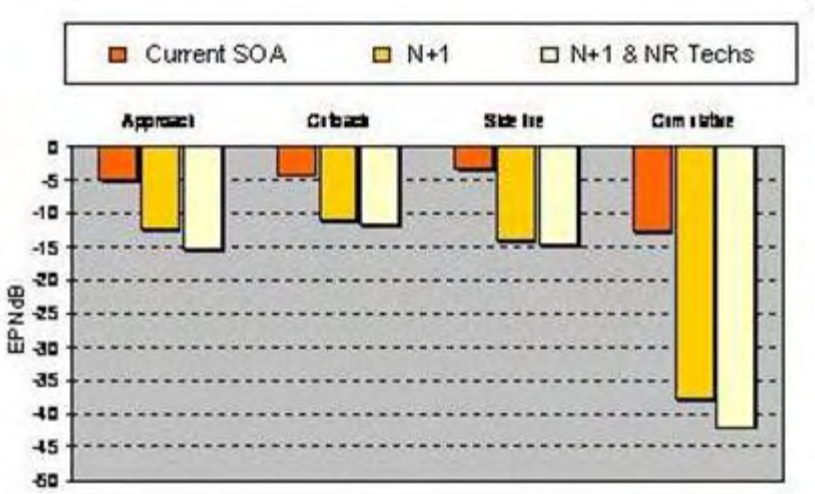
- Conduct Discipline-based Foundational Research

****Fuel burn for N+2 vehicle concepts being validated*

Noise

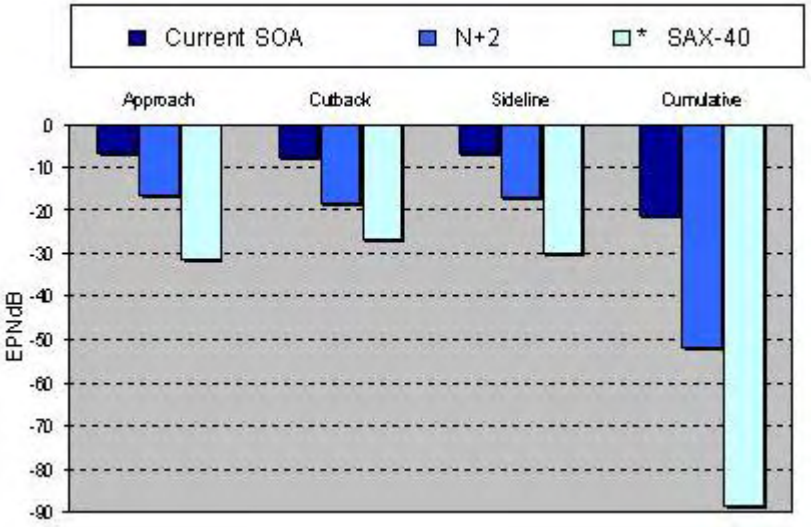
“N + 1” Conventional Small Twin

- 42 EPNdB cumulative below Stage 3
- Target Next Generation Single Aisle (NGSA)
- Ultra-High Bypass (UHB) engines
- Noise Reduction (NR) technologies for fans, landing gear, propulsion airframe aeroacoustics
- Light weight acoustic treatment in multi-functional structures



“N + 2” Hybrid Wing/Body

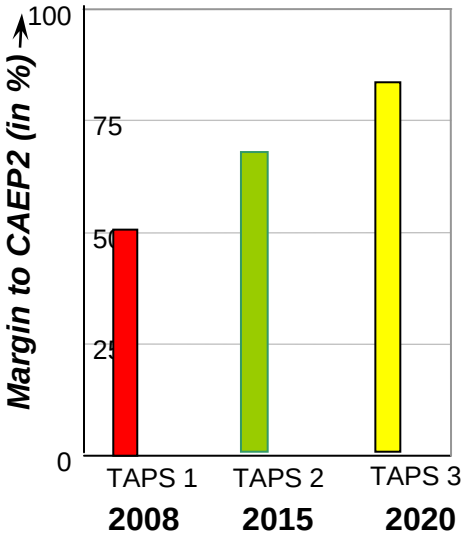
- 52 EPNdB cumulative below Stage 3
- Will achieve significant noise reduction from wing shielding of engines
- Drooped leading edge
- Continuous mold line flaps
- Landing gear fairings
- Long duct, low drag acoustic liners
- Distortion tolerant fans with active noise control



Emissions

"N + 1" Conventional Small Twin

- 70% LTO NOx reduction below CAEP/2
- Target Next Generation Single Aisle (NGSA)
- Annular combustor TAPS2 (GE)
  - Improved fuel/air mixers
- TALONX (P&W)
  - Optimized quench section for improved mixing
  - Improved fuel/air mixing in rich zone

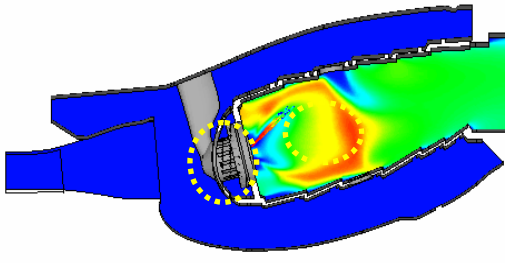


"N + 2" Hybrid Wing/Body

- 80% LTO NOx reduction below CAEP/2
- Alternative combustor concepts (like flameless catalytic)
- Advanced fuel/air mixers
- Active combustion control
- High temperature combustor liners
- Alternative fuels

Strategy: ***Increase fuel/air mixing in time and space, minimize combustion zone residency time, maintain unburned hydrocarbon and particulate burnout***

Lean Direct Injection Multipoint Concept

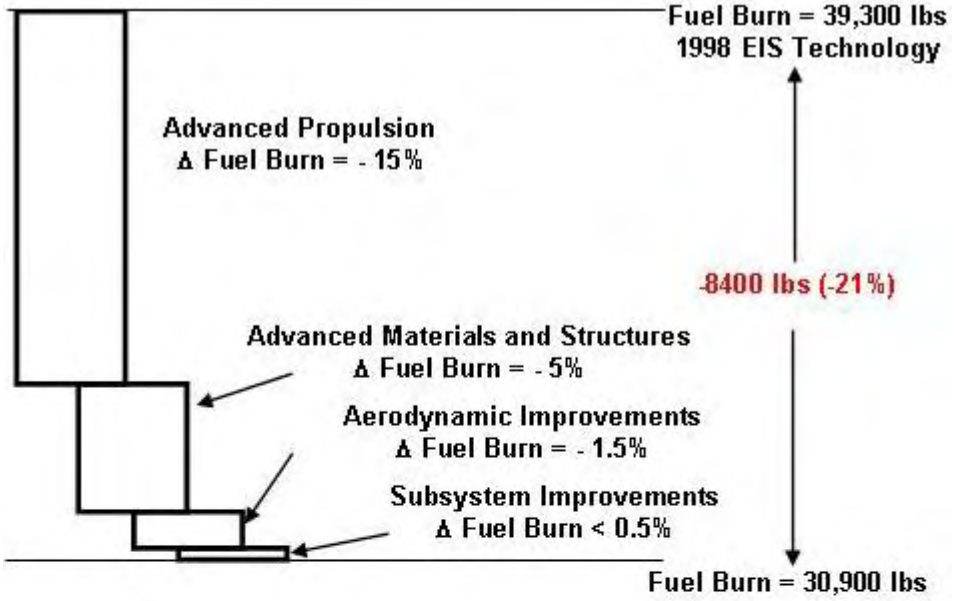


Rich Burn Quick Quench Lean Burn Concept

Performance - Fuel Burn

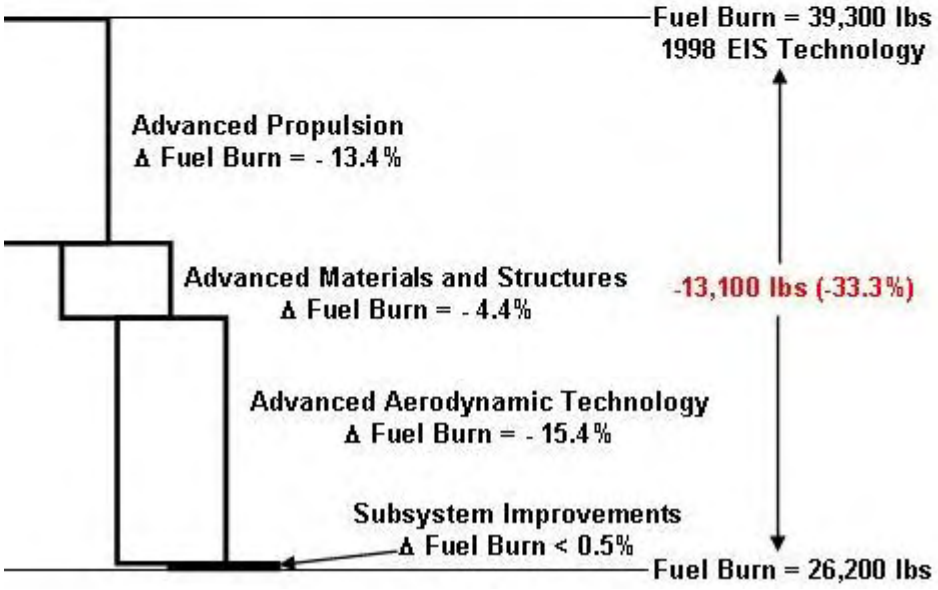
"N + 1" Conventional Small Twin

- 162 pax, 2940 nm mission baseline
- Ultra high bypass ratio engines, geared
- Key technology targets:
  - +1 point increase in turbomachinery efficiencies
  - -25% improved turbine cooling effectiveness and advanced materials
  - +50 deg. F compressor temperatures (T3)
  - +100 deg. F turbine rotor inlet temperatures
  - -15% airframe structure weight
  - -1% total vehicle drag
  - -15% hydraulic system weight



"N + 1" Advanced Small Twin

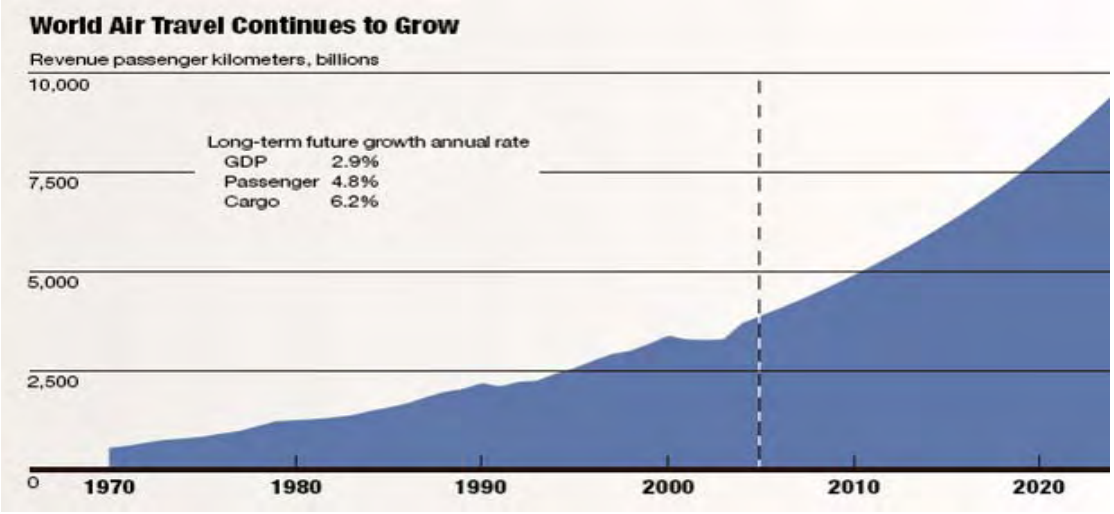
- All technologies listed above plus:
  - Hybrid Laminar Flow Control (67% upper wing, 50% lower wing, tail, nacelle)
  - -17% total vehicle drag



Note: "N+2" fuel burn studies concluding later this year

Performance - Field Length

NextGen ATS to enable 2-3x growth in air travel by 2025



Barriers to Growth

- Noise
- Emissions
- Capacity

Key Aircraft Capability

•STOL (field length ≤ 3000 ft) with low noise and efficient high-speed cruise (Mach 0.8+)

Key Partnership for Tool & Technology Development

•NASA/OGA/Industry

Key Aircraft Technology

•Powered Lift/Flow Control Concepts for Reduced Field Length

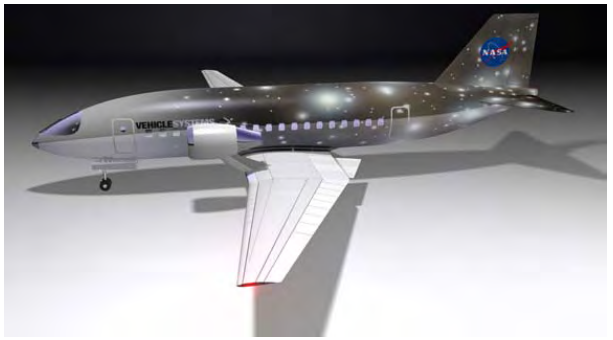
Key Tools

•3D Flow Control Prediction Tools (CFD)

•3D Flow Control Test Capability (WT)

Cruise Efficient STOL Aircraft Concepts

N+1



N+2

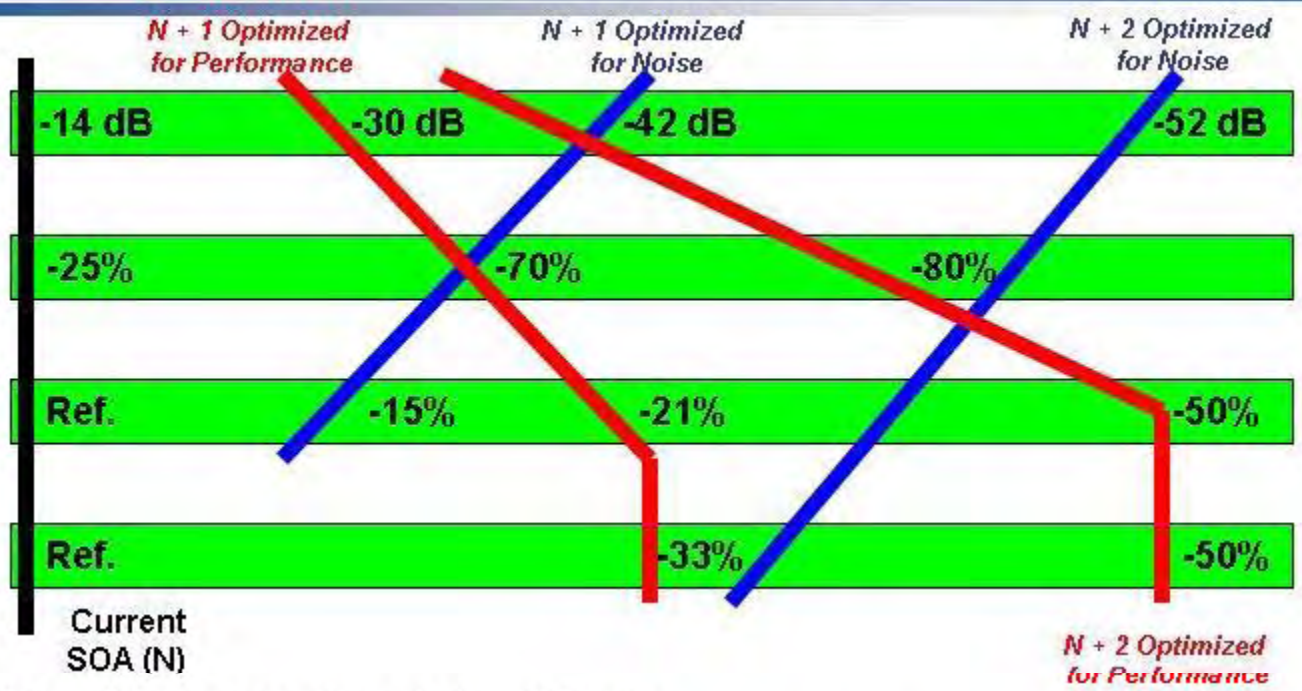
Optimization - Performing Trades

Noise
Cum below Stage 3

Emissions
LTO NOx below CAEP/2

Performance
Aircraft Fuel Burn relative to 737/CFM56

Performance
Field Length relative to 737/CFM56



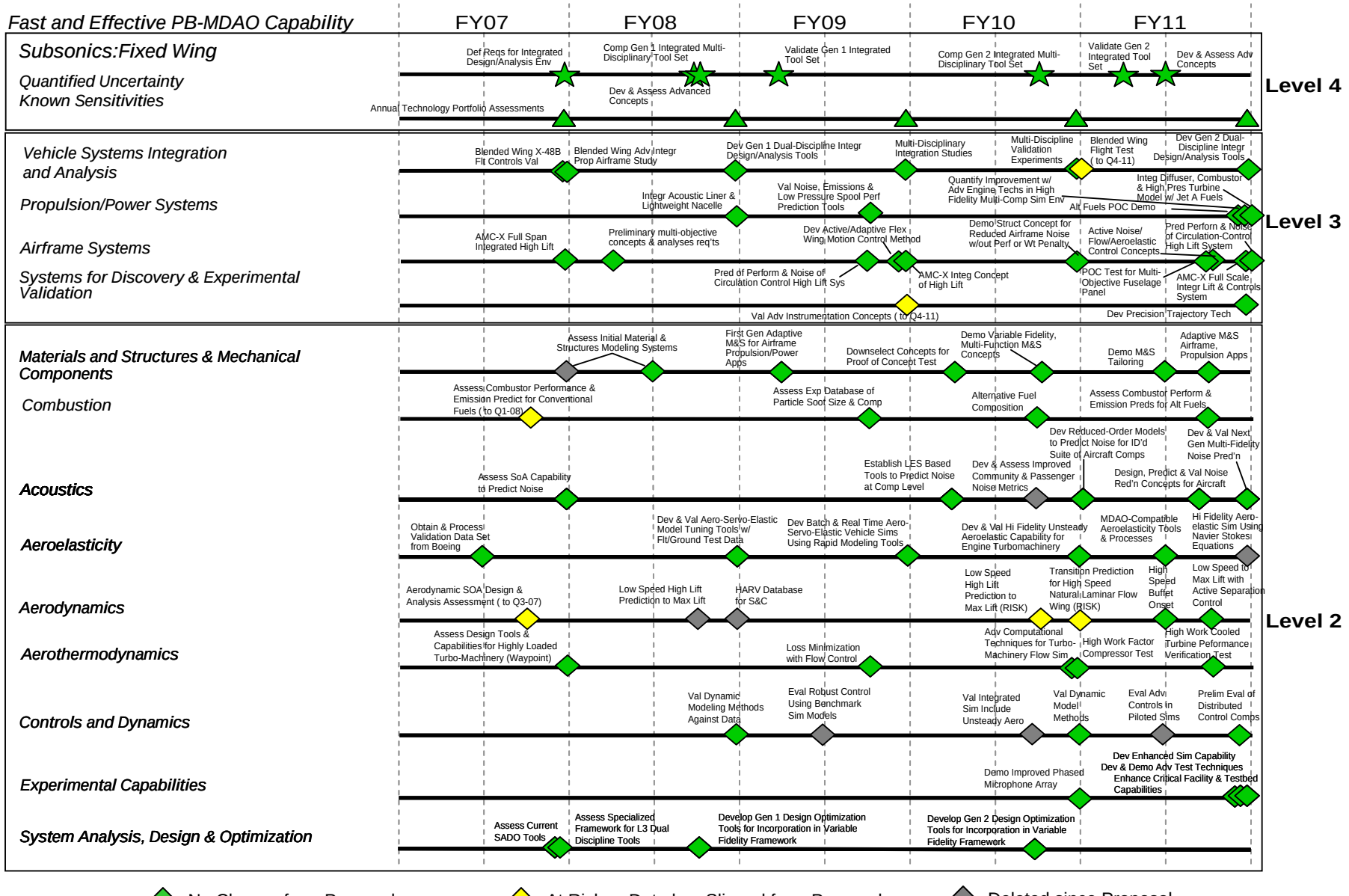
"N + 1" Conventional Small Twin

- Technologies available for 2012 – 2015 EIS (market permitting)
- Noise: UHB engines, reduced weight, low-noise fans & landing gear
- Emissions: advanced combustors (TAPS, TALONX, etc.)
- Performance: high power density engine cores, reduced weight, high lift

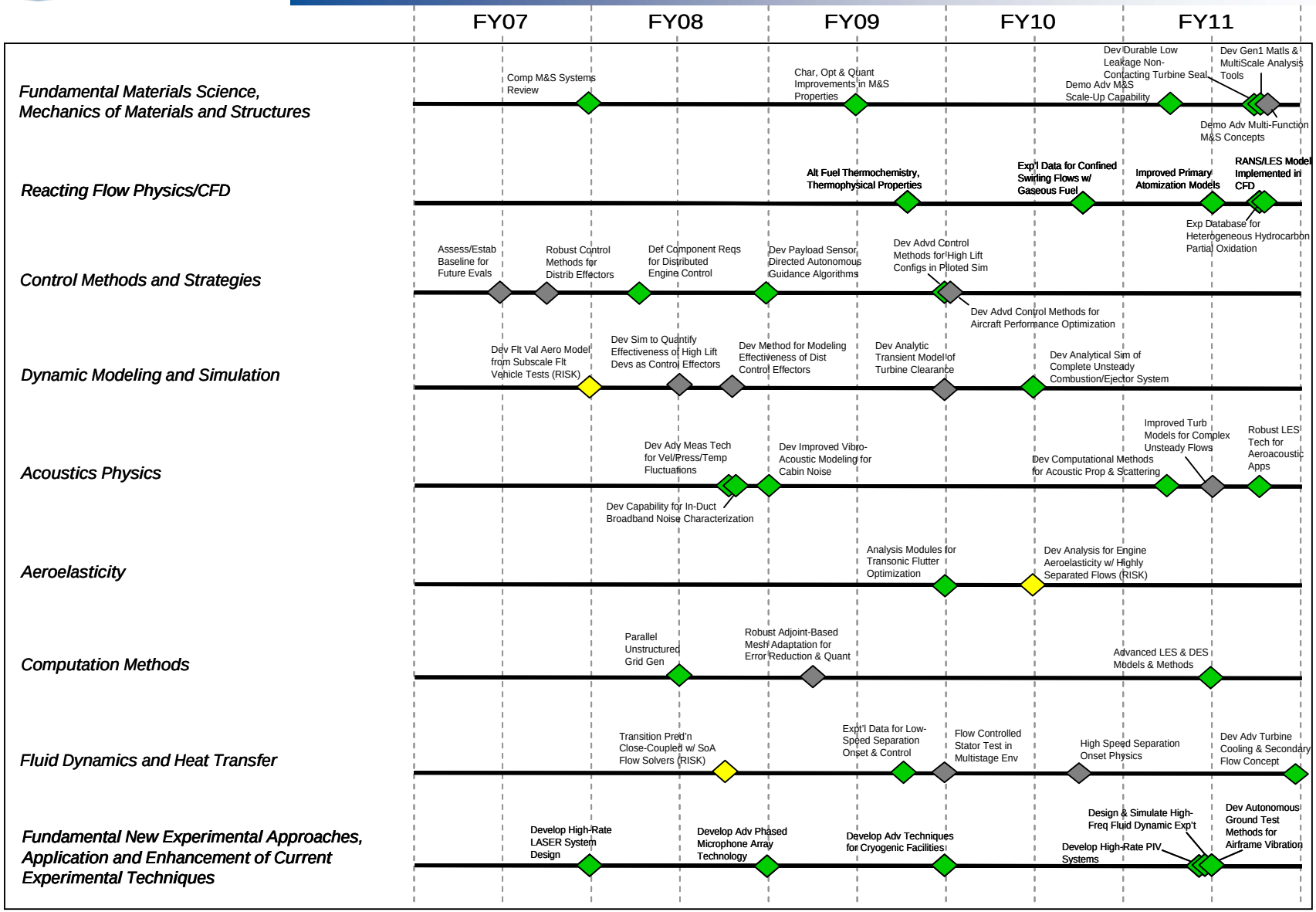
"N + 2" Hybrid Wing/Body

- Technologies available for 2018 – 2020 Initial Operational Capability
- Noise: shielding from above wing engines, low-noise airframe
- Emissions: alternative fuels, alternative combustion concepts
- Performance: embedded engines, morphing structures, low drag
- Balanced Field Length: cruise efficient STOL, high lift

Schedule of Milestones



Schedule of Milestones - cont'd



Level 1

No Change from Proposal

At Risk or Date has Slipped from Proposal

Deleted since Proposal

Key Deliverables and Milestones

FY07

- Baseline state-of-the-art analysis methods and tools to address aeronautics challenges within the hypersonic, subsonic (for rotary and fixed wing vehicles), and supersonic flight regimes
- Blended wing/body X-48B flight controls validation

FY08

- Develop and test concepts for conventional aircraft configurations that establish feasibility of achieving Stage 3-42 EPNdB (cum) noise reduction
- Develop and test concepts for unconventional aircraft configurations that establish the feasibility of achieving short take-off and landings on runways less than 3000 ft.
- Complete GEN 1 integrated multi-disciplinary tool set

FY07 Highlights

- UHB Geared Turbo Fan Test in the GRC 9x15 (Pratt and Whitney)
- Airframe noise test at Wallops (Gulfstream)
- Cruise Efficient STOL Concept Test in LaRC 14x22 (AFRL/NGC)
- BWB X-48B Low Speed Vehicle Flight Test at DFRC (AFRL/Boeing PW)
- MDAO strategy, framework and requirements documents complete
  - Validated GEN 1 Capability - low to medium fidelity (FY09)
  - Validated GEN 2 Capability - medium to high fidelity (FY11)
- Technical Working Groups Implemented
- NASA Research Announcements - 2 Rounds Complete, 1 pending (advanced aircraft concepts beyond 2025)

SFW Conference Overview
Grand Salon A

- Noise Prediction and Mitigation (Tuesday, 1:30 pm)
  - Acoustics Discipline Overview
  - Aircraft Noise Prediction Program Developments
  - Acoustic Prediction State-of-the-Art Assessment
  - Chevron Nozzle LES Computations
  - Airframe Noise Benchmark Problems for Unsteady Computations
  - Engine Validation of Noise Reduction Technology

SFW Conference Overview (cont'd)
Grand Salon A

- Aircraft Performance Improvements (Wed. 8:00 am)
  - Aerodynamics Overview
  - Aerodynamics CFD Assessment (with Q and A)
  - Foundational Circulation Control Experiments
  - Aerothermodynamics Overview and Prediction Assessment (with Q and A)
  - Highly Loaded Turbine Research Program
  - Materials and Structures Overview
  - Materials and Structures State-of-the-Art Assessment
  - Enhancing the Design Space with Unitized Structures

SFW Conference Overview (cont'd)
Grand Salon A

- Emissions Prediction and Mitigation (Wed. 1:30pm)
  - Combustion Discipline Overview
  - Assessment of the National Combustion Code
  - Integrated Multi-Phase and Combustion Modeling for Large Eddy Simulation in Realistic Gas-Turbine Combustors
  - Large Eddy Simulation of Spray Combustion in Swirling Flows
  - NASA 9-point LDI Code Validation Experiment
  - Development of Standard Practices for Characterizing Gas-Turbine Engine Particle Emissions

SFW Conference Overview (cont'd)
Grand Salon A

- SFW Project Partnerships (Thursday, 8:00 am)
  - Advancing MDAO
  - UHB Ratio Engine Research for Reducing Noise, Emissions, and Fuel Consumption
  - Quiet Technology Research for Low Noise Airframes
  - Aerostructures Research for Increased Performance
  - Research for Enabling Cruise Efficient STOL Vehicles
  - Hybrid Wing Body Enabling Research

SFW Conference Overview (cont'd)
Grand Salon A

- SFW Feedback Session (Thursday, 1:30 pm)
  - Is the SFW Project investing in important and relevant research areas that meet the long term needs of the nation
  - What are the gaps and missing pieces of the project
  - Are there areas that should be scaled back
  - How can we best get project information/output to you
  - Is there an area of collaboration that interests you

First hour will be open format

Call 216-287-1123 for 15 min. one-on-one appointments starting at 2:40pm

Questions