National Aeronautics and Space Administration

NASA Aeronautics

Environmentally Responsible Aviation Project

Real Solutions for Environmental Challenges Facing Aviation

Presented by: Fay Collier



AIAA ASM 2012
NASHVILLE, TN

NASA's Subsonic Transport System Level Metrics Alignment with National R&D Policy and Plan

	TECHNOLOGY GENERATIONS (Technology Readiness Level = 4-6)		
TECHNOLOGY BENEFITS*	N+1 (2015)	N+2 (2020**)	N+3 (2025)
Noise (cum below Stage 4)	- 32 dB	- 42 dB	- 71 dB
LTO NOx Emissions (below CAEP 6)	-60%	-75%	-80%
Cruise NOx Emissions (rel. to 2005 best in class)	-55%	-70%	-80%
Aircraft Fuel/Energy Consumption‡ (rel. to 2005 best in class)	-33%	-50%	-60%

* Projected benefits once technologies are matured and implemented by industry. Benefits vary by vehicle size and mission; N+1 and N+3 values are referenced to a 737-800 with CFM56-7B engines, N+2 values are referenced to a 777-200 with GE90 engines

** ERA's time phased approach includes advancing "long-pole" technologies to TRL 6 by 2015

‡ CO_2 emission benefits dependent on life-cycle CO_{2e} per MJ for fuel and/or energy source used

ERA Project Approach – Focus on N+2 Timeframe

Develop advanced vehicle concepts envisioned for integration into the fleet by 2025

Simultaneous reduction of noise, NOX, and fuel burn at vehicle level

Develop key technologies envisioned for advanced vehicle concepts

Advance TRL and IRL for key technologies to 5 or 6 by 2015

ERA Project – Key Technical Focus Areas and Technical Challenges

(1) Innovative Flow Control Concepts for Drag reduction

TC – Reduce fuel burn by 6 percent while minimizing maintenance issues

(2) Advanced Composites for Weight reduction

TC – Reduce aircraft weight by 10 percent over SOA composites while maintaining safety margins at the aircraft system level

(3) Advanced UHB Engine Designs for Specific Fuel Consumption and Noise Reduction

TC – Reduce fuel burn by 20 percent while reducing engine system noise and while minimizing weight, drag and integration penalties at AC system level

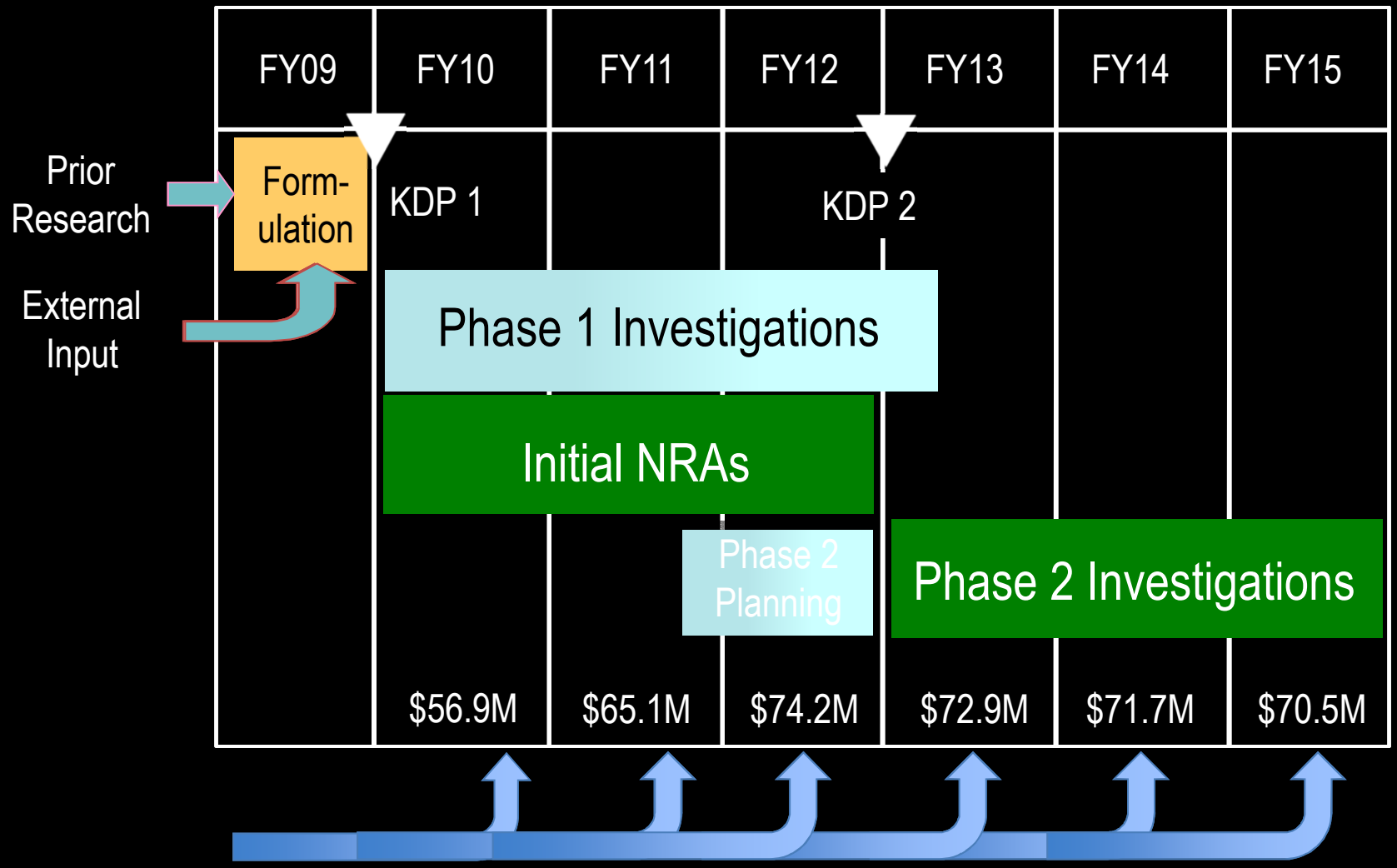
(4) Advanced Combustor Designs for Landing Takeoff Oxides of Nitrogen reduction

TC – Reduce LTO NOX by -75 percent while reducing fuel burn by 50 percent at the aircraft system level

(5) Airframe and Engine Integration Concepts for Community Noise Reduction

TC – Reduce component noise signatures while minimizing weight and integration penalties at aircraft system level to achieve 42 EPNdB margin to Stage 4

ERA Project Flow
With Key Decision Points



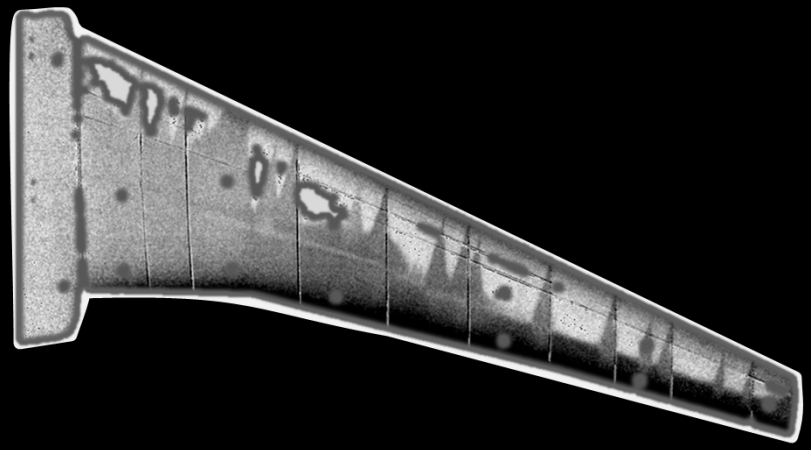
Technical input from Fundamental Programs, NRAs, Industry, Academia, Other Gov't Agencies

ERA FY 10-11 are actual full cost
ERA FY 12-15 budget numbers from President's FY12 budget

Phase I Investigations

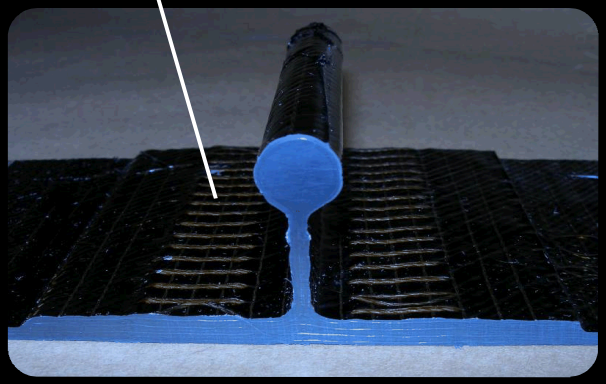
Reduce Mission Fuel Burn and Community Noise

1 DRAG REDUCTION - Via Laminar Flow



2 WEIGHT REDUCTION

PRSEUS – Pultruded Rod Stitched Efficient Unitized Structure



3 SFC/NOISE REDUCTION

Integration of Advanced UHB Engines for Zero Installation Drag



Phase I Investigations

Reduce Mission Fuel Burn and Community Noise

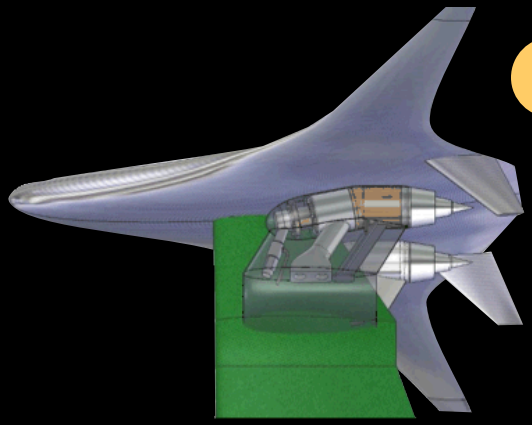
1 AIRFRAME NOISE
High-lift Systems and Landing Gear





2 PROPULSION NOISE
Fan, Core and Jet Noise

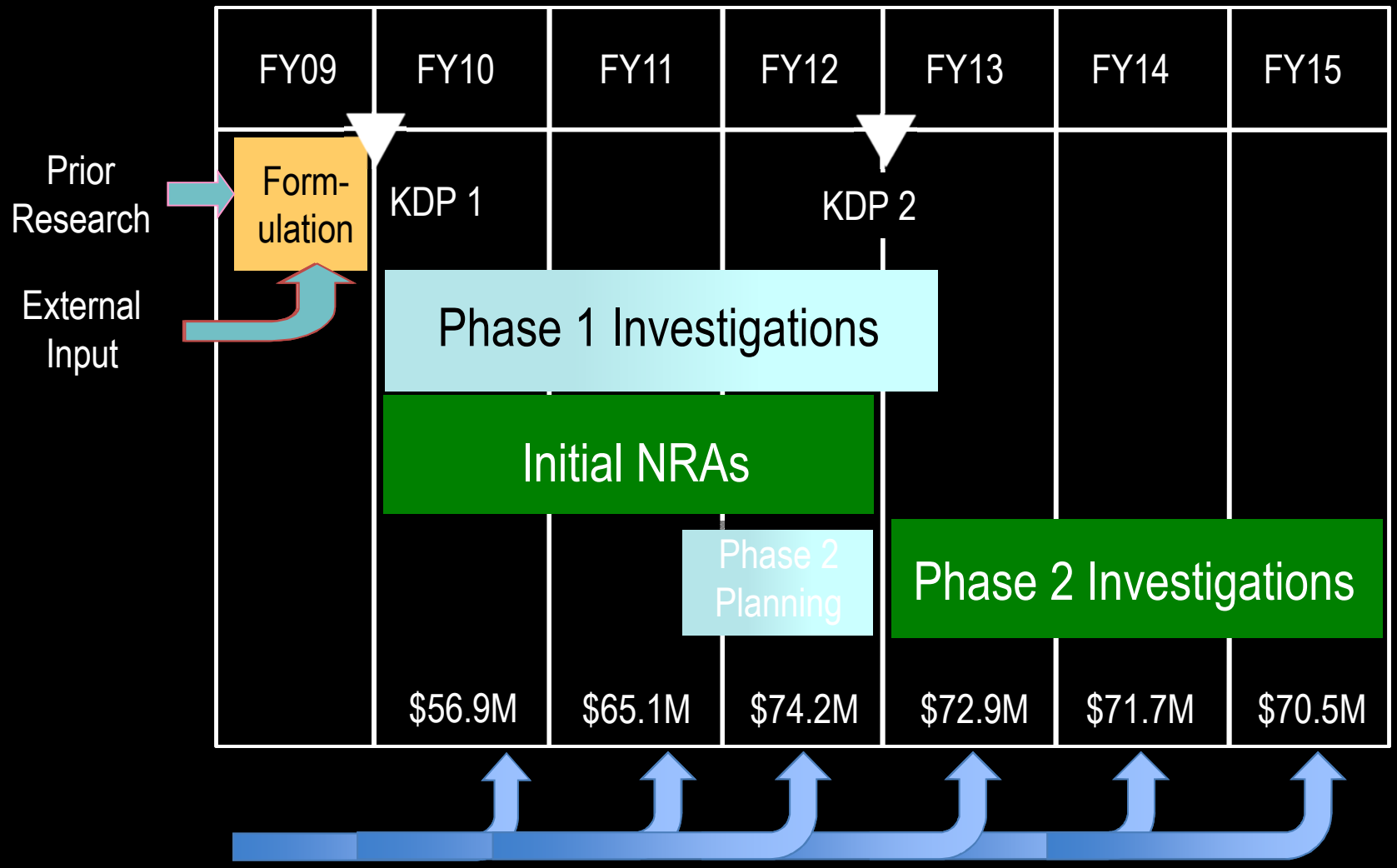




3 PROPULSION AIRFRAME AEROACUSTICS
Airframe/Propulsion Interaction & Shielding

ERA Project Flow

With Key Decision Points



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

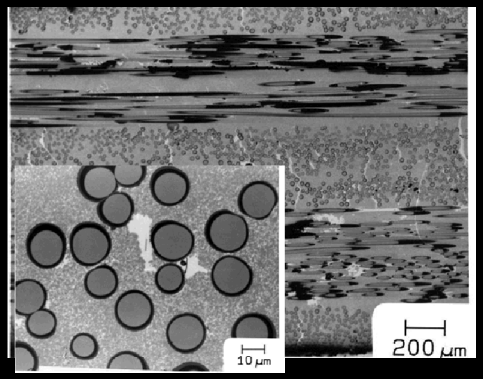
ERA FY 10-11 are actual full cost

ERA FY 12-15 budget numbers from President's FY12 budget

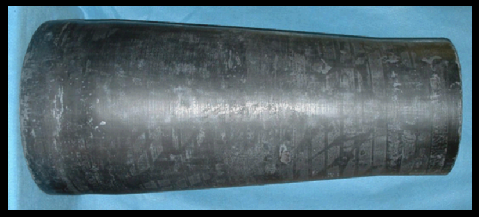
Initial NRAs

Advanced Low Nox Fuel Flexible Combustor Design

1 CMC COMBUSTOR LINER
For higher engine temps

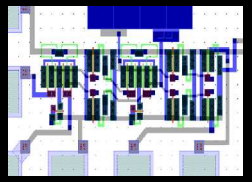


SIC CMC Concepts

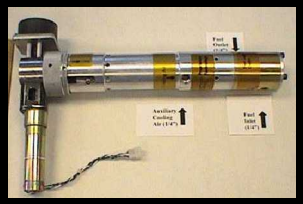


CMC combustor liner

2 INSTABILITY CONTROL
Suppress combustor instabilities

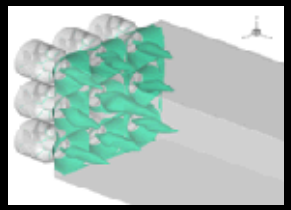


High Temperature SiC electronics circuits and dynamic pressure sensors

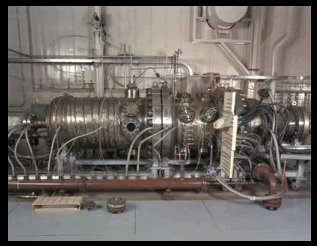


Fuel Modulation for high frequency fuel delivery systems

3 LOW NOX, FUEL FLEXIBLE DESIGN/TEST



Innovative Injector Concept



ASCR Combustion Rig

Initial NRAs

Advanced Vehicle Concepts

- The Study
  - Twelve months in duration
  - Five tasks
    - Tasks 1-4 relate to a full sized concept
    - Task 5 relates to a subscale testbed vehicle
  - $10.9M total awarded to three teams

Advanced Vehicle Concepts NRA

Task 1



- Future Scenario
  - What does the world that you are designing to look like?
    - What are your assumptions that are driving your design?
  - What is the NextGen scenario in 2025 that you are designing to?
    - What level of completion is NextGen at?
  - What is the interplay between your concept and NextGen?
    - How would you like NextGen to be tweaked to accommodate your PSC?

Preferred System Concept (PSC)

Task 2

- Develop a conceptual design of a 2025 EIS subsonic transport – passenger and/or cargo
- Compile Concept Data Packages
  - Configuration geometry and dimensions
  - Drag polars and performance predictions
  - Weight statement
  - Propulsion system performance and weights
- Compile Concept Data Packages for:
  - 1998 tube and wing
    - Baseline system analysis toolset
  - 2025 EIS tube and wing
    - Separate configuration from technology

Technology Development Roadmaps

Tasks 3 & 4

- Technology Maturation Plans (TMP's)
  - 15 year Roadmap for each of the critical technologies
    - Key research, analyses, tool and method development
    - Necessary ground and flight tests
  - Starting and ending TRL & SRL
  - Cost, schedule and technical outcome
- FY 2013 – 2015 Critical Technology Demonstrations
  - Long poles and enabling technologies
  - Scalability
  - Sorted and prioritized by:
    - Airframe
    - Propulsion
    - Integrated Propulsion/Airframe
    - Subscale Testbed

Subscale Test-bed Vehicle

Task 5

- Conceptual Design of a Subscale Testbed Vehicle (STV)
- Proposal for completing Preliminary Design of the STV
- ROM cost and schedule for completing design, construction and initial flight testing of the STV
- STV requirements
  - Same configuration as the PSC
  - Same Mach and cruise speed as PSC
  - Retractable Landing Gear
  - Sufficient scale to demonstrate noise, emissions & fuel burn goals
  - Adaptable/reconfiguarable for future modifications
  - Avionics capable of UAS Integration into NAS research
  - Projected 10,000 hour, 20-year research life

Envisioned Uses
Subscale Test-bed Vehicle

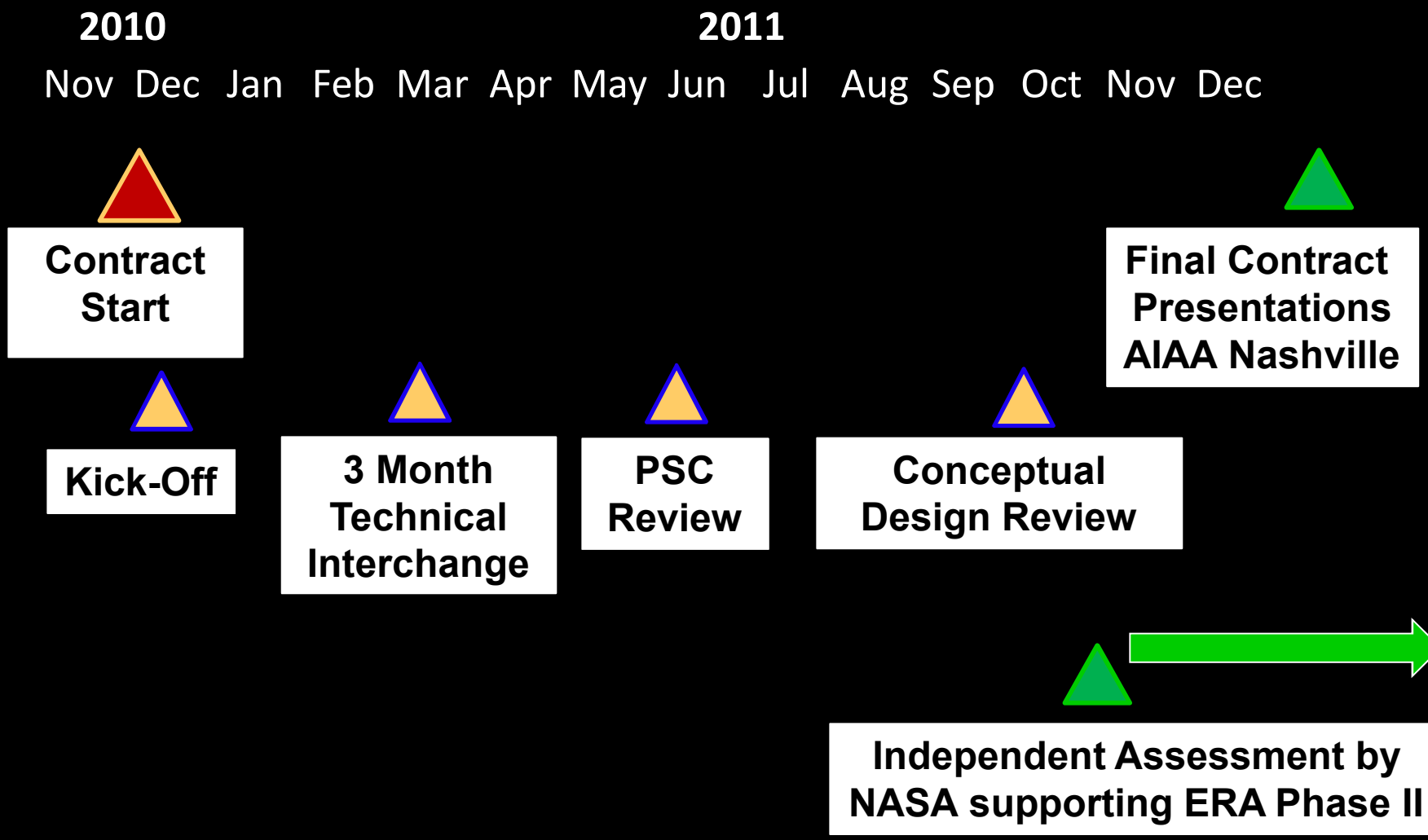
- Future project 2016 – 2020
  - First flight and flight qualification
  - Integrated portfolio demonstration
  - Spiral technology development

- UAS into the NAS Research Program 2020 – 2025

- SFW integration flight research 2025 - 2030

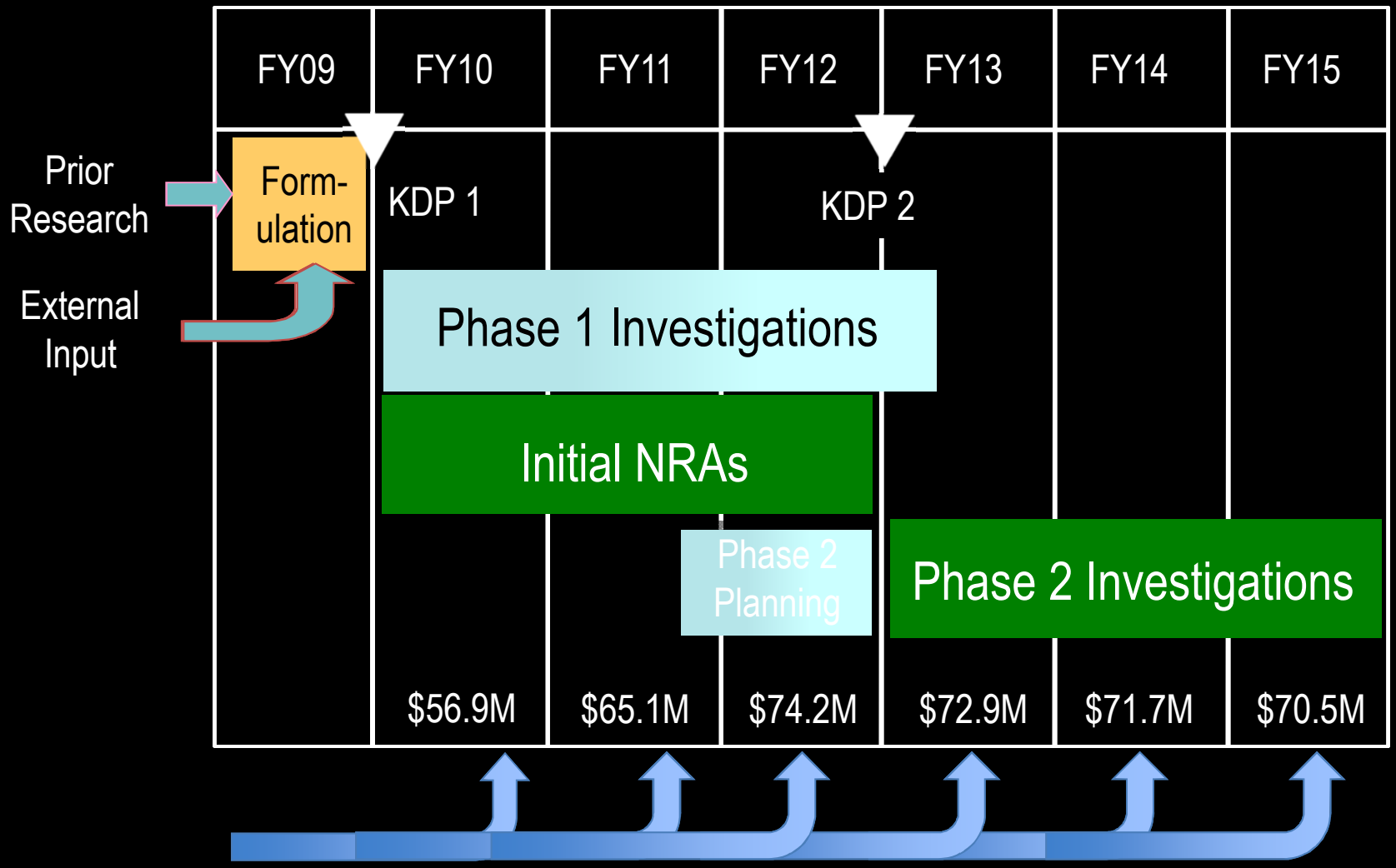
STV Cost is heavily dependent upon level of integration of technology and validation of advanced structural systems

AVC Contract Timeline



ERA Project Flow

With Key Decision Points



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

ERA FY 10-11 are actual full cost

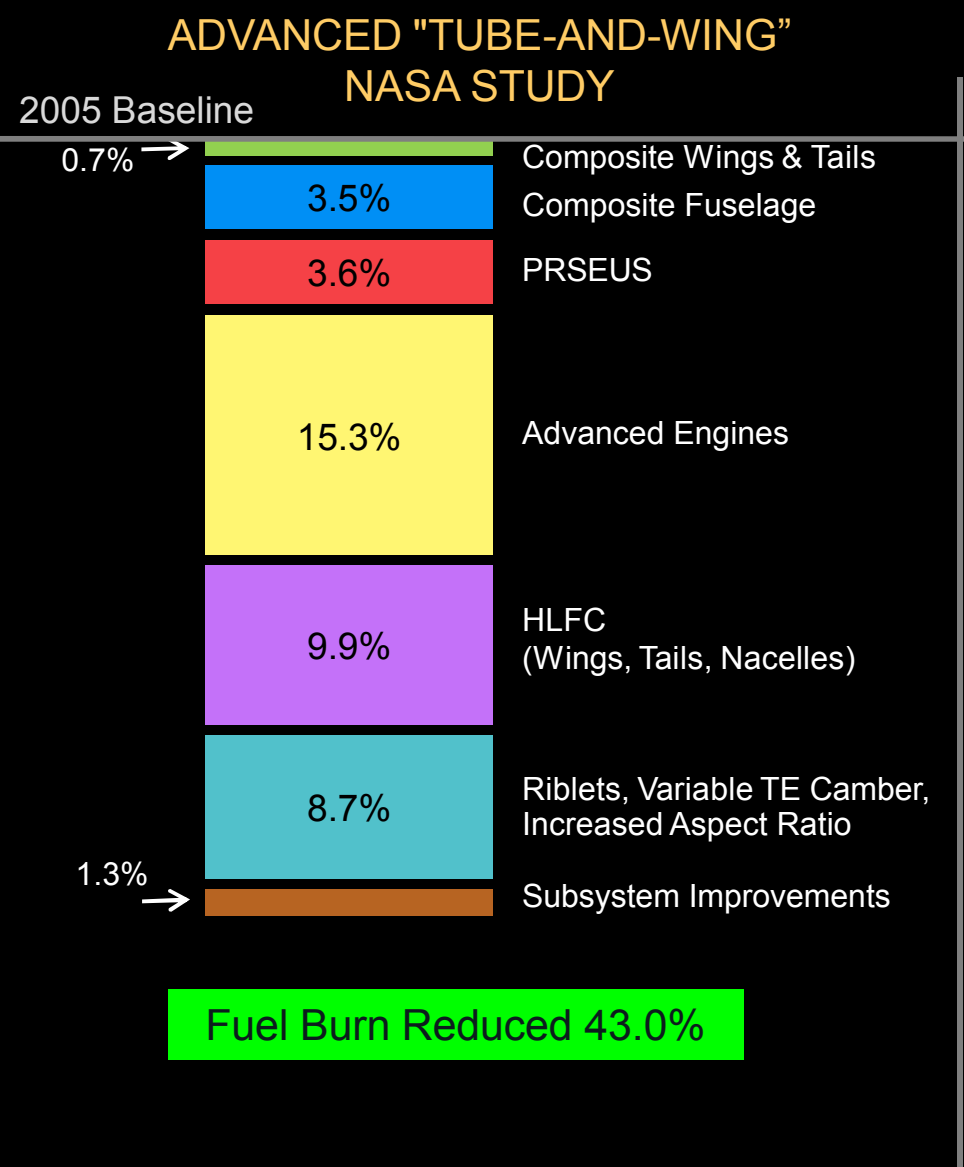
ERA FY 12-15 budget numbers from President's FY12 budget

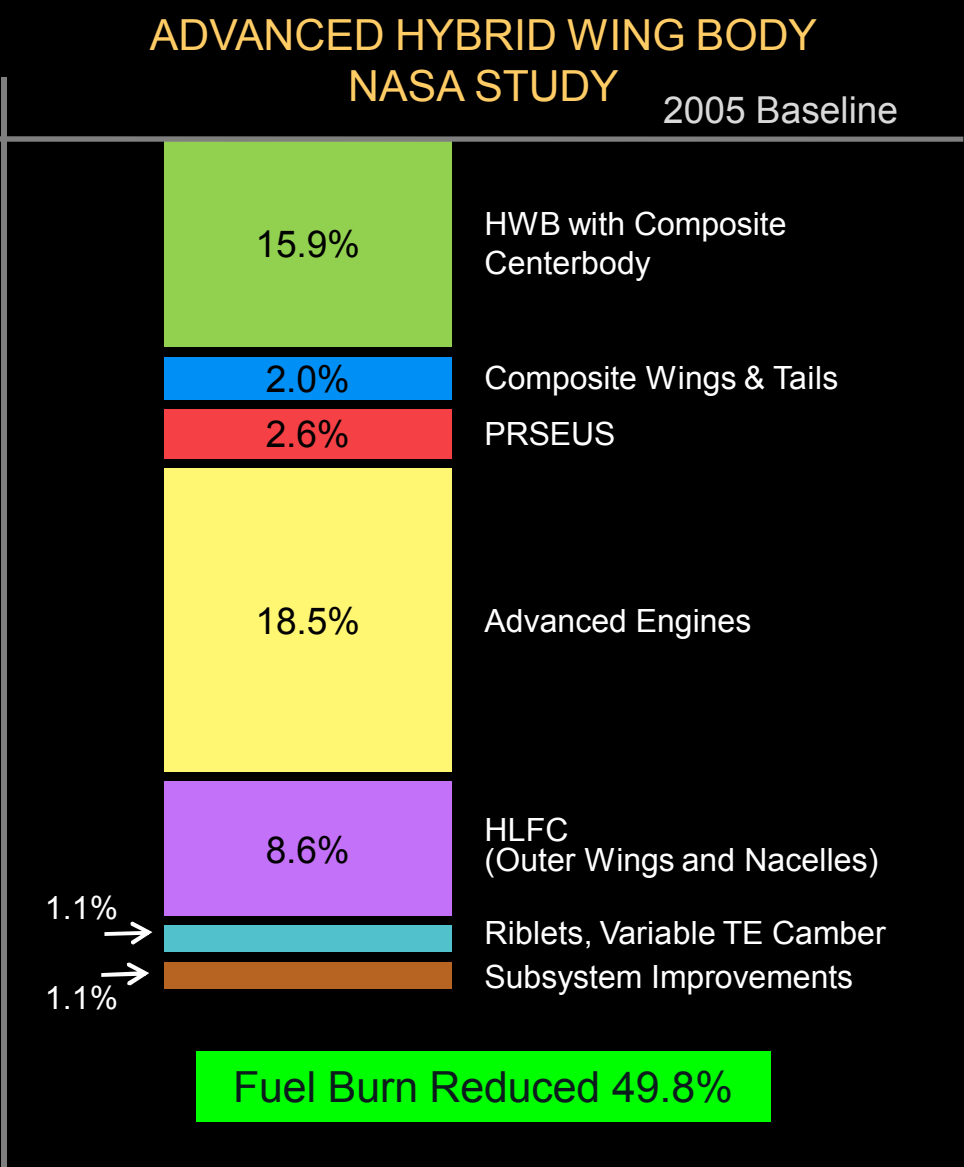
ERA Phase 2
Planning Activities and Timeline

- ERA Phase II Planning Team Kickoff — Oct
- KDP – 2 Technical Review — Feb
- KDP – 2 Meeting of Experts — Mar
- ERA Detailed Planning/Solicitations — Apr-Jul
- KDP – 2 Authority to Proceed — Aug

Projected Integrated Portfolio Benefits

Mission Fuel Burn/Carbon Emissions



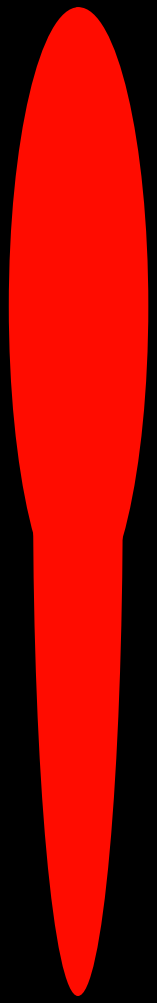


Projected Integrated Portfolio Benefits

Community Noise Reduction

SINGLE TAKEOFF AND LANDING CYCLE

Current Rule:
Stage 4
Baseline Area





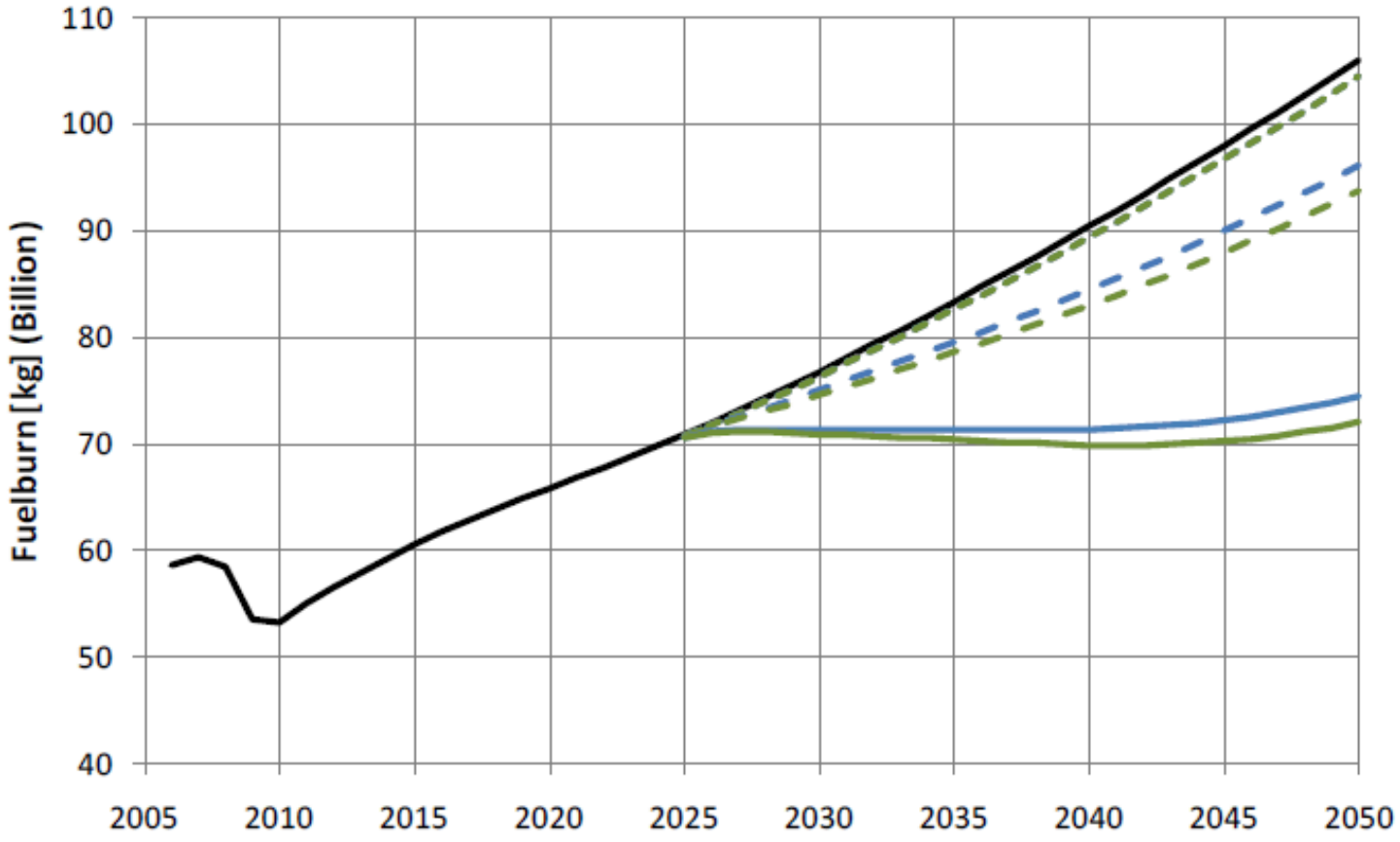
State of the Art
Stage 4 – 10 dB CUM
Area = 55% of Baseline



N+2 GOAL
Stage 4 – 42 dB CUM
Area = 8% Baseline

Projected Integrated Portfolio Benefits

Fleet Wide Mission Fuel Burned Reduction



436 Billion kg Fuel Saved

From Mavris, Schutte, Jimenez, Pfaender, etc. Georgia Tech, AIAA 2011-6882, etc.