

# Status of ERA Vehicle System Integration Technology Demonstrators

## Oral Presentation

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The Environmentally Responsible Aviation (ERA) Project within the Integrated Systems Research Program (ISRP) of the NASA Aeronautics Research Mission Directorate (ARMD) has the responsibility to explore and document the feasibility, benefits, and technical risk of air vehicle concepts and enabling technologies that will reduce the impact of aviation on the environment. The primary goal of the ERA Project is to select air vehicle concepts and technologies that can simultaneously reduce fuel burn, noise, and emissions. In addition, the ERA Project will identify and mitigate technical risk and transfer knowledge to the aeronautics community at large so that new technologies and vehicle concepts can be incorporated into the future design of aircraft.

There are three technology demonstrations within the Vehicle Systems Integration sub project. 1) Flap Edge & Landing Gear Noise Reduction Flight Experiment; 2) Ultra-High Bypass Ratio (UHB) Engine integration for Hybrid Wing Bodies; and 3) Active Flow Control (AFC) Enhanced Vertical Tail & Advanced Wing Flight Experiment. Each of these technology demonstrations address a technical challenge in the ERA technology portfolio.

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The Flap Edge & Landing Gear Noise reduction Flight Experiment and UHB Engine Integration for HWB both address the challenge to *Demonstrate reduced component noise signatures leading to 42 EPNdB to Stage 4 noise margin for the aircraft system while minimizing weight and integration penalties to enable 50 percent fuel burn reduction at the aircraft system level.*

The AFC Enhanced Vertical Tail & Advanced Wing Flight Experiment addresses the challenge to *Demonstrate drag reduction of 8 percent, contributing to the 50 percent fuel burn reduction goal at the aircraft system level, without significant penalties in weight, noise, or operational complexity.*

This presentation will give an overview and status of the research efforts to date for each of the above technology Demonstrations.

### **Flap Edge & Landing Gear Noise Reduction Flight Experiment**

This technology demonstration seeks to reduce airframe noise during aircraft landing, supporting total aircraft noise reduction of greater than or equal to 42.0 EPNdB. NASA worked with partner Gulfstream to mitigate radiated airframe noise (Flaps = 4.5 EPNdB, MLG = 3.5 EPNdB) during aircraft landing through development of effective noise reduction (NR) technologies applicable to current and future generations of civil transports. An aeroacoustic test was conducted in the NASA LaRC 14x22 tunnel on an 18% semi-span model to evaluate novel airframe noise reduction concepts in a realistic environment.

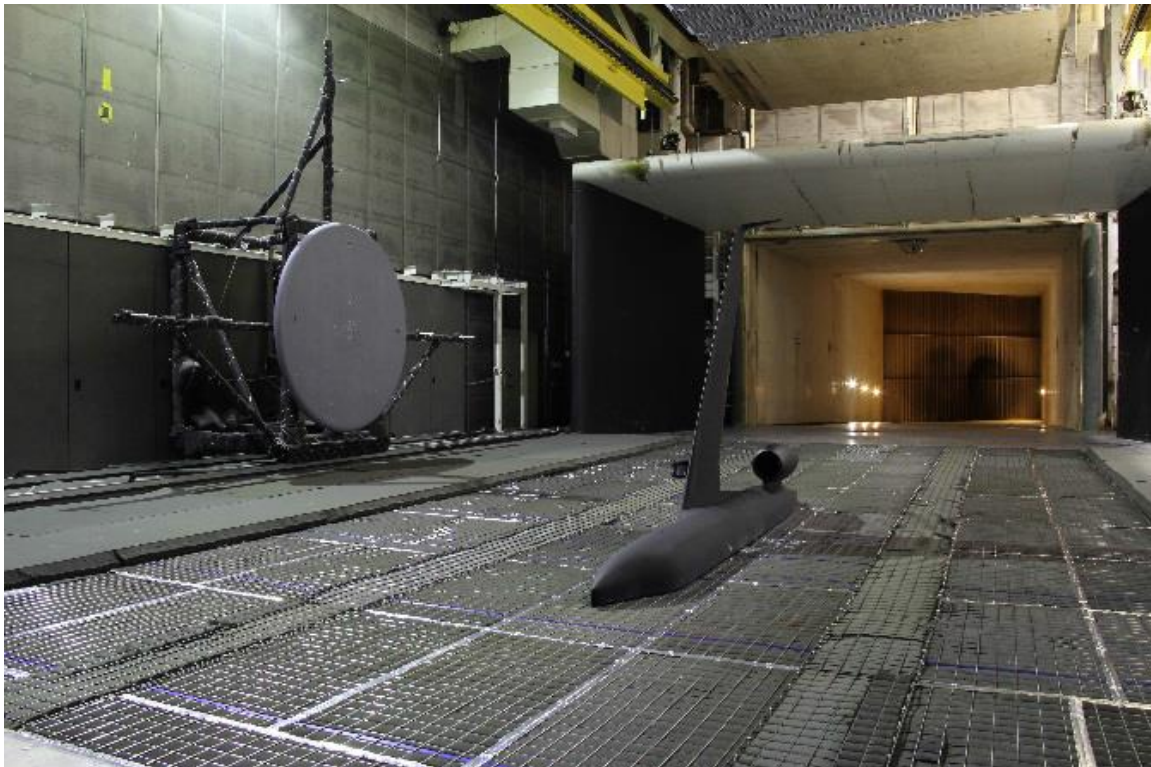


Figure 1: 18% Semi-span Model Aeroacoustic Test in 14x22  
with Phased Microphone Array (AIAA 2014-2478)

### **Ultra-High Bypass Ratio (UHB) Engine integration for Hybrid Wing Bodies**

This technology demonstration seeks to quantify the impact of engine/ airframe integration on HWB system performance and engine operability across key on- and off-design conditions. Its goal is to demonstrate an HWB propulsion airframe integration (PAI) design concept that will enable fuel burn reductions in excess of 50% (1% drag penalty) while providing noise shielding required to meet ERA noise reduction metrics (Figure 2). NASA partnered with Boeing to design and verify an HWB PAI concept that minimizes adverse propulsion/airframe induced interference effects that could result in high drag or poor aerodynamic characteristics. NASA and Boeing will use computation fluid dynamics predictions (CFD) and a series of wind tunnel tests to: quantify key design trade space issues that impact UHB engine operability in HWB concepts and minimize the impact of adverse effects; Characterize the impact of airframe dominated flows on the fan stall margin of a UHB concept; Characterize the impact of propulsion induced flows on the performance and stability and control of a HWB configuration. A 5.75% scale model of the HWB concept will be tested in the NASA LaRC 14x22 Low Speed Wind Tunnel in a series of tests (Figure 3): 1) A flow-through nacelle test for aerodynamic assessment of the high lift system; 2) Powered ejector test to investigate inlet flowfields and distortion at the inlet face; and 3) Turbine Powered Simulator (TPS) test to assess power effects. The HWB concept's high speed cruise performance will be evaluated using CFD.



Figure 2: Artist rendering HWB aircraft concept



Figure 3: HWB model installed in the NASA LaRC 14x22 Low Speed Wind Tunnel

### **Active Flow Control (AFC) Enhanced Vertical Tail & Advanced Wing Flight Experiment**

This technology demonstration will accelerate, integrate, and demonstrate active flow control (AFC) technology to achieve drag reduction goals. Its goal is to develop and demonstrate the AFC-enhanced vertical tail technology through full-scale wind tunnel testing and flight testing to achieve a 20% side force improvement that will lead to 1 to 2% reduction in drag and fuel burn. NASA partnered with Boeing to develop an Active Flow Control (AFC) technology to enhance the rudder control authority of commercial transport aircraft; Obtain full-scale wind tunnel data on the AFC-enhanced vertical tail at flight-relevant conditions; Obtain flight test data to characterize the performance of the AFC-enhanced vertical tail under dynamic conditions, including rudder deflection and sideslip angle.

A full scale Boeing 757 tail assembly with integrated flow control actuators (sweeping jets) was tested in the AEDC National Full-Scale Aerodynamic Complex 40x80 foot tunnel at NASA's Ames Research Center in preparation for flight testing on the B757 ecoDemonstrator (Figure 4).





Figure 5 – B757 ecoDemonstrator Aircraft (courtesy Boeing)