



Backgrounder

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The Boeing ecoDemonstrator Program

To support the long-term sustainable growth of aviation, Boeing looks for opportunities to improve commercial aviation's environmental performance throughout an airplane's lifecycle.

The Boeing ecoDemonstrator Program plays a key role in the company's environmental strategy by using flight testing to accelerate new technologies that can reduce emissions and noise, improve airlines' gate-to-gate efficiency and help meet other environmental goals. Proven ecoDemonstrator technologies and processes may be incorporated into existing production models, made available for in-service fleets and applied to new airplane development programs.

To date, the ecoDemonstrator Program has tested more than 50 technologies using three airplanes as flying test beds. More than 15 technologies were tested on an American Airlines 737-800 in 2012. In 2014, more than 25 technologies were tested on the Boeing-owned 787 Dreamliner ZA004. In 2015, the ecoDemonstrator Program tested more than 15 technologies on a 757 in collaboration with NASA and TUI Group.

Suppliers, airlines, government agencies and other organizations have partnered with Boeing on ecoDemonstrator testing. In June 2015, Boeing and Embraer announced that they will collaborate to test ecoDemonstrator technologies in a joint effort to improve aviation's environmental performance. The companies plan to flight test technologies on an Embraer airplane in 2016, expanding cooperation between two of the world's largest airplane manufacturers.

The ecoDemonstrator Program follows the successful Boeing Quiet Technology Demonstrator (QTD) program. In 2001, Boeing and Rolls Royce developed a quieter engine using saw-toothed chevrons on the rear of the nacelle and exhaust nozzles. Additional testing in 2005 refined the chevron design and validated an acoustically

treated engine inlet. The result was the application of the new chevrons on the 787 Dreamliner and the 747-8, providing dramatic noise reductions for both new models.

ecoDemonstrator 737 (2012)

The ecoDemonstrator Program formally began in 2011 in cooperation with American Airlines and the FAA. With an inaugural flight in 2012, 15 new technologies were tested on an American Airlines Next-Generation 737-800 airplane.

The ecoDemonstrator 737 was used to validate additional aerodynamic performance of natural laminar flow technology on the new 737 MAX Advanced Technology Winglet, which improves fuel efficiency by up to 1.8 percent.

Additional technologies tested on the ecoDemonstrator 737 include:

- Variable area fan nozzle
- Active engine vibration control
- Regenerative hydrogen fuel cell
- Flight trajectory optimization
- Carpet made from recycled materials
- Blended biofuel

ecoDemonstrator 787 (2014)

The ecoDemonstrator Program began flight tests with 787 Dreamliner ZA004, a company-owned airplane, in mid-2014. Partners in ecoDemonstrator 787 testing included the U.S. Federal Aviation Administration (FAA) Continuous Lower Energy, Emissions and Noise (CLEEN) program, NASA Environmentally Responsible Aviation (ERA) Project, Japan Airlines, Delta Air Lines, Rolls Royce, Honeywell, Rockwell Collins, General Electric and Panasonic, among others.

In July, Boeing and FAA CLEEN, a competitively bid five-year program with costs shared by participants, completed testing of the Ceramic Matrix Composite (CMC) engine nozzle. Made of high strength, heat resistant ceramic, the CMC nozzle is designed to enable engines to operate at a higher temperature, improving fuel efficiency while decreasing emissions and noise.

In late 2014, the ecoDemonstrator 787 evaluated more than 25 additional technologies to make flights more fuel efficient and quieter. They included aerodynamic

and flight control improvements; ice-phobic wing coatings to reduce ice accumulation; and software applications and connectivity technologies that can improve flight planning, fuel-load optimization, in-flight routing and landing.

On the ecoDemonstrator 787, NASA tested its Airborne Spacing for Terminal Arrival Routes (ASTAR), based on Flight Interval Management, to help achieve precise spacing between aircraft upon landing. The technology is intended to increase landing frequency and reduce holding patterns, saving fuel, emissions and time.

In December 2014, Boeing completed the world's first flight using "green diesel," a sustainable biofuel that is widely available and used in ground transportation. The company powered the ecoDemonstrator 787 flight test airplane with a blend of 15 percent green diesel and 85 percent petroleum jet fuel in the left engine. During several additional test flights, the ecoDemonstrator used the same 15 percent blend of green diesel in both engines. Boeing is using data generated by the flights to support industry approval of green diesel for commercial aviation.

Other technologies on the ecoDemonstrator 787 included touch-screen displays in the flight deck, wireless sensors that can reduce wiring and outer wing access doors made from recycled 787 carbon fiber.

ecoDemonstrator 757 (2015)

In March 2015, the ecoDemonstrator 757 took to the skies to evaluate new technologies to improve commercial aviation's efficiency and reduce noise and carbon emissions. Boeing collaborated with TUI Group and NASA on these 757 tests.

The airplane was painted in the livery of Europe-based TUI Group, the world's number one integrated tourism group, which includes six airlines. TUI Group collaborated on the ecoDemonstrator Program as a way to reduce aviation's environmental impact, including carbon emissions.

On the left wing of the ecoDemonstrator 757, Boeing tested technologies to reduce environmental effects on natural laminar flow as a way to improve aerodynamic efficiency, including a Krueger shield to protect the leading edge from insects.

Boeing was under contract with NASA's Environmentally Responsible Aviation (ERA) Project to test two technologies on the 757. With the exception of Boeing

proprietary technology, NASA knowledge gained in collaboration with Boeing from ecoDemonstrator research will be publicly available to benefit the industry.

On the vertical tail, NASA and Boeing tested active flow control to improve airflow over the rudder and maximize its aerodynamic efficiency. Based on NASA wind-tunnel testing, active flow control could improve the rudder's efficiency by about 17 percent and may allow for a smaller vertical tail design in the future.

On the 757's right wing, NASA tested "bug-phobic" coatings that can reduce drag from insect residue; this would enable more laminar flow by smoothing the air flow on the surface of the wing.

In June 2015, Boeing flew the ecoDemonstrator 757 using a 5 percent blend of "green diesel" produced in the U.S., to support ongoing industry efforts to approve this biofuel for use in commercial aviation.

The ecoDemonstrator 757 also tested:

- Solar and thermal "energy harvesting" to power electronic dimmable windows, as a way to reduce wiring, weight, fuel use and carbon emissions.
- A 3D-printed aisle stand made from excess carbon fiber from 787 production, an example of its efforts to re-purpose aerospace-grade carbon fiber and reduce airplane weight and factory waste.

In August 2015, Boeing collaborated with Stifel's aircraft finance division, which owned the airplane, as well as the Aircraft Fleet Recycling Association and an airplane demolition company in Spokane, Wash., to dismantle and recycle the 757 using environmental best practices. Including parts and materials, about 90 percent of the airplane (by weight) was reused or recycled, with 10 percent going to a landfill.

For more information, visit www.boeing.com/environment

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