Sound innovation

At a remote site in Montana, Boeing tests new commercial jetliner technologies that benefit the industry—and the environment

By James Wallace and photos by Bob Ferguson

During the Farnborough International Airshow in July, Mike Carriker, the Boeing test pilot who flew the 787 Dreamliner on its first flight in 2009, provided journalists with a running commentary as the carbon-fiber aircraft performed for huge crowds during one of its daily flying demonstrations.

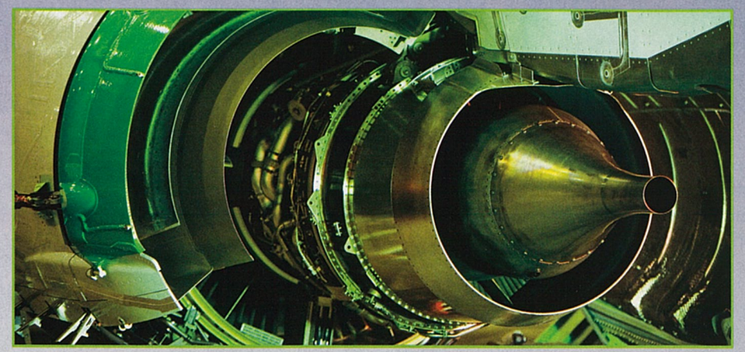
"Now listen. Just listen," Carriker said as the 787 came in to land.

The journalists, watching from the balcony of the Boeing media chalet, fell silent as they focused on the 787 approaching the runway from about a quarter mile away. They heard nothing until the Dreamliner was almost directly in front of them, one later wrote.

Commercial jetliner technology has come a long way from the noisy 707 that pioneered jet service in the 1950s. The 787 is the world's most technologically advanced jetliner, one that Boeing engineers made as friendly as possible for passengers and the environment. But more advancements are on the way that will make commercial jets even more quiet, while improving fuel burn and lowering carbon dioxide emissions. And reducing the environmental footprint of the world's passenger planes, be it from noise or emissions, is one of the aerospace industry's top priorities.

Several of these new technologies are already being tested on the first aircraft of Boeing's ecoDemonstrator program, a 737-800.

After the testing is completed, test equipment will be removed and the plane returned to its factory-new condition, and the Next-Generation 737 will be delivered to American Airlines. But until then, the 2012 ecoDemonstrator is a flying laboratory that



PHOTOS: (Below) The ecoDemonstrator 737-800 prepares for a sunrise test flight at the Montana Aviation Research facility in Glasgow, Mont. **(Insets)** The ecoDemonstrator technology includes wing and engine innovations that will improve fuel burn and reduce noise and carbon dioxide emissions.

showcases just how much more is possible.

In September, Boeing test pilots flew ecoDemonstrator from Seattle to Glasgow, Mont., for about three weeks of extensive testing. One of the pilots participating in the testing is Carriker, now chief pilot for New Airplane Development, Boeing Test & Evaluation.

Glasgow, in the northeastern corner of Montana, is the perfect place to measure how much noise a jetliner makes—it's pretty much in the middle of nowhere. During World War II, the airfield was used to train B-17 pilots, and in late 1944 a camp was built there to house German prisoners of war. In the 1960s, a B-52 strategic bomber wing was located at what by then was Glasgow Air Force Base. The base closed in the 1970s and much of the property was purchased by Boeing as an aircraft test facility. Today, the site is maintained by Montana Aviation Research Co., a Boeing subsidiary. Billings and Great Falls, the two nearest cities with commercial airline passenger flights, are hundreds of miles away.

The remoteness of the site, the lack of background noise, no air traffic and a massive 13,500-foot (4,100-meter) runway make it ideal for flight testing. It's essentially a supersensitive listening post—for all kinds of noise made by an airplane.

Scattered about the site and under the flight path taken by Boeing test aircraft is a phased array of microphones. They work like an acoustic camera and can pinpoint specific aircraft sounds, even the noise made by turbulence from the movement of control surfaces on the wing during landing. Nearly 2,000 different listening devices were deployed for the ecoDemonstrator testing at Glasgow to measure both airframe and community noise.

"We can actually tell which component on the plane is making the noise," explained David Akiyama, ecoDemonstrator program manager.

Noise heard on the ground is referred to as "community noise." During takeoff operations, this mostly comes from the engines. But on landing, both engine noise and airframe noise, such as that made by turbulence from the wing flaps and the landing gear, contribute to community noise.

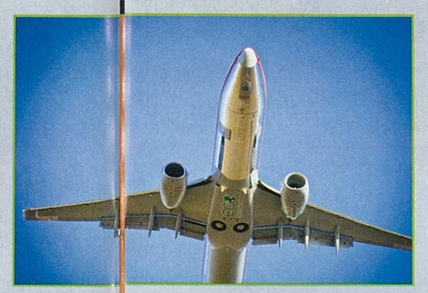
Among the technologies on the ecoDemonstrator tested at Glasgow is an "adaptive trailing edge," which improves airflow at the trailing edge of the wing. This smart wing technology allows the wing aerodynamics to be optimized for each phase of flight—takeoff, cruise and landing. On takeoff, for example, the airplane climbs faster, which means less community noise because the airplane spends less time close to the ground. During cruise, the trailing edge adjusts to reduce airplane drag to lower fuel burn and reduce carbon dioxide emissions.

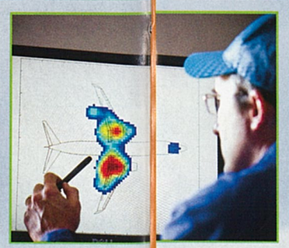
Akiyama referred to this innovation as "wing morphing." Think of a bird in flight, he said. A bird will change the shape of its wings depending on whether it's climbing, gliding, diving or landing.

"So we change the shape of an airplane wing for various flight conditions," he said.

Another important technology on ecoDemonstrator tested at Glasgow is a "variable area fan nozzle," which opens the engine

PHOTOS (Below): An aerial view of the acoustical array of microphones, used to pinpoint aircraft noise, at the end of the main runway at the Glasgow site. **(Insets, clockwise from top left)** The ecoDemonstrator team in Glasgow included: Steve Rapp; Tim Rahmes holding an iPad; Noel DePeralta; Dave Russell installing test sensors, Chief Pilot Mike Carriker on the flight deck; Kristin Crawford; and Kevin Johnson.





fan exhaust nozzle area by up to 10 percent. During takeoff, the engine operates more efficiently with a larger fan nozzle. Essentially, the same amount of thrust is produced by moving a larger amount of air through the nozzle at a slower speed.

"It's more efficient to move a large volume of air at lower velocity, more comparable to the airplane's speed, than a lower amount of air through a smaller nozzle at a faster speed for the same amount of thrust," Akiyama explained. "It also reduces community noise."

Akiyama pointed out that the engines on the early 707s were very noisy and less fuel-efficient because they sported turbojets or low-bypass turbofans with very high exhaust jet velocities.

"Newer planes are getting bigger and bigger fans," he noted.

A number of other technologies also are being tested on ecoDemonstrator, from regenerative fuel cells for onboard power to carpet tiles made of recycled materials. Worn or damaged carpet tiles could be replaced individually during service, which would lower maintenance costs since the entire carpet would not need to be replaced as often. And landfill waste would also be reduced since the tiles are completely recyclable.

The ecoDemonstrator program is made possible through funding provided to Boeing Research & Technology by the U.S. Federal Aviation Administration's CLEEN program, short for Continuous Lower Energy, Emissions and Noise. The adaptive wing trailing edges, as well as the ceramic composite engine nozzles, are two of the technologies that are being developed by a team of Boeing researchers for the CLEEN program. Experts believe ceramic composites offer the potential for better thermal and structural performance, while helping to reduce weight and noise.

The program also builds on the company's Quiet Technology Demonstrator programs that led to a number of noise-reduction technologies tested at Glasgow and later incorporated on the 787 and 747-8, including chevrons, the sawtoothed aerodynamic devices at the rear of the engine nacelle and on the exhaust nozzle of Boeing's two newest jets.

After the 737-800 ecoDemonstrator is delivered to American Airlines, a Boeing-owned 787 will be used as the 2013 ecoDemonstrator. Preliminary planning for ecoDemonstrator test flights in 2014 and beyond has already started.

Akiyama has been on the ecoDemonstrator program for three years. "You are bringing all the best parts of Boeing together," he said. That includes Commercial Airplanes, Boeing Test & Evaluation and Boeing Research & Technology.

"It's all about accelerating technology and innovation," he added. And flight-test programs such as ecoDemonstrator are one of the best ways of doing that. ■

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To learn more about ecoDemonstrator, see Page 22 in the May 2012 issue of Boeing Frontiers *or view a video at www.boeing.com/Features/2012/09/bca_eco_demonstrator_09_17_12.html*

PHOTOS: (Top) The 2012 ecoDemonstrator lifts off the runway for another round of flight testing over Glasgow. **(Insets, clockwise from top left)** The ecoDemonstrator team in Glasgow included: Kristin Crawford, from left, Meredith Anderson and Wayne Wenneman analyzing the flight-test plan; Barry Finnelly, left, and John Wasilewski preparing for a flight; Jessica Lee working on the fuel cell; Joey Reed; Leon Brusniak looking over noise data; Cederic Daniels, left, and Pat Cappetto; and Tom Alston and Dean Parham (kneeling) preparing the variable area fan nozzle.