

Flying INTO THE future

ecoDemonstrator program speeds technology development that helps industry and the environment

By Karen Crabtree and photos by Bob Ferguson

At a lab near Seattle's Boeing Field, Tim Rahmes has spent two years developing new turbulence and water vapor sensors that, if successful, would allow commercial airplane pilots to stop hunting for the smoothest air—and wasting precious fuel in the process.

So Rahmes, lead engineer and principal investigator on the project, has a lot riding on the outcome of the 2014 ecoDemonstrator program. His improved weather forecasting tools, and the algorithm he developed to run them, will be among 30 environmental technologies tested on board a specially outfitted 787 during several weeks of test flights over the remote desert of Moses Lake, Wash.

"I'm excited to fly this and highlight things I know will be groundbreaking

PHOTO: The 2014 ecoDemonstrator test airplane, a 787-8, taxis at Moses Lake in Eastern Washington. The airplane has been specially outfitted to flight-test 30 environmental technologies.

for the industry,” Rahmes said. “Having better weather forecasting information to improve flight efficiency and reduce fuel use—that helps everyone in our industry.”

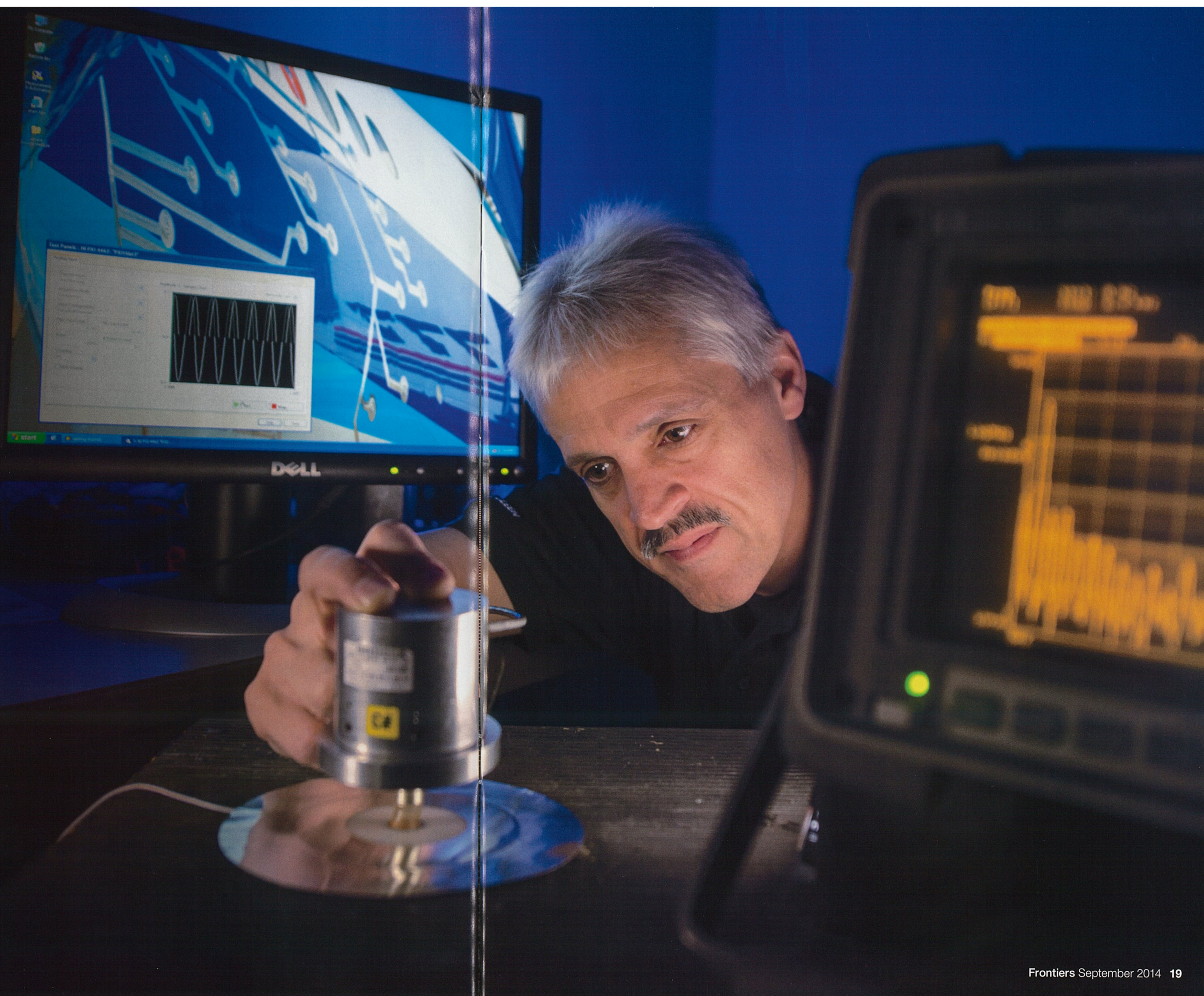
Boeing’s ecoDemonstrator program, launched in 2011, is designed to speed up the process of testing and refining new technologies to improve aviation’s environmental performance. The program’s first test flights were conducted in 2012. That year, the program used an American Airlines 737-800 as its flying laboratory, or test bed, to evaluate 15 technologies. One of them, natural laminar flow technology, was later incorporated into the 737 MAX Advanced Technology Winglet design to further enhance the airplane’s fuel efficiency.

This year the ecoDemonstrator program has doubled in size, testing technologies from software that will provide pilots with improved weather and route information to hardware designed to lower weight, save fuel and reduce airplane noise heard on the ground. The program’s 787 began early test flights in July, but the majority of the testing will take place this fall.

“The ecoDemonstrator program picks up the pace of development, and that helps engineers get excited about technology development,” said David Akiyama, ecoDemonstrator program manager.

The 787 ecoDemonstrator flights will help evaluate such innovations as advanced navigation landing systems, enhanced aerodynamics, and airplane parts made from recycled materials such as carbon fiber. Additionally, the ecoDemonstrator teams are working toward a paperless flight deck, potentially eliminating the 40 to 50 pounds (18 to 23 kilograms) of charts and paperwork that pilots bring on board, by testing mobile devices such as tablets on the

PHOTO: Jim Underbrink, of Boeing Test & Evaluation Instrumentation & Data Systems, uses a calibration device to determine sensitivity on a microelectromechanical system, or MEMS, microphone that was tested as part of the ecoDemonstrator program.



flight deck, said Brian Gilbert, flight-deck displays lead.

While the touch-screen mobile devices will be used to provide pilots with more real-time data to fly more-efficient routes, converting installed flight-deck hardware controls to touch screens saves weight in the flight deck, which contributes to improved fuel use.

Collectively, these innovations could point the way to the next big advance in aviation, explained Jeanne Yu, Boeing Commercial Airplanes director of Environmental and Features Strategy.

"It's like the saying, Many raindrops make a river," Yu said. "It's not that one technology solves everything, and it's not one big problem we are solving. It's a lot of technologies—we are working on all those many technologies that will add up to a big benefit."

Boeing is the only major airplane manufacturer with a test plane dedicated exclusively to evaluating environmentally progressive technologies, according to Akiyama.

Traditionally, engineers designed new technologies to coincide with the introduction of upcoming airplane models or derivatives, Akiyama pointed out, which resulted in 10- to 15-year lags between opportunities to see their technologies in action in a flight-test program. The ecoDemonstrator, with a full schedule of test flights every 12 to 18 months, allows new technologies to be tested as soon as they are ready, speeding implementation on commercial jetliners.

Boeing has tested new technologies through airborne "demonstrators" since at least the early 2000s, when it completed two Quiet Technology Demonstrator programs. The noise-canceling chevrons, or serrated edges, visible on the engine casings of today's 747-8 and 787 Dreamliner, grew from that program.

Aviation already is one of the most environmentally efficient ways to travel. Julie Felgar, Commercial Airplanes managing director of Environmental Strategy and Integration, said new airplanes are comparable to electric cars in the amount of fuel they use

per passenger mile. But with fuel costs jumping to nearly 40 percent of an airline's operating costs, even a 1 percent reduction can have a big impact on an airline's bottom line.

Conscious of the need to minimize its environmental footprint, the industry has established big goals for the future of airline travel, including a commitment to carbon-neutral growth from 2020 and a 50 percent reduction in carbon emissions by 2050.

"That's not a lot of time," Felgar said. "The ecoDemonstrator program allows us to accelerate along that timeline to meet those goals. For me, that's the most exciting part—to see how the ecoDemonstrator inspires our suppliers, customers and others in our industry."

The program, managed by Commercial Airplanes Product Development, leverages



PHOTO: Bill Lucyk, left, and Derek Baesler of Boeing Test & Evaluation complete checks on installation of the engine exhaust nozzle made of ceramic matrix composites, designed to make engines quieter, lighter and more efficient.

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the talents of employees in Boeing Research & Technology, Boeing Test & Evaluation, and many Commercial Airplanes departments, including Environmental Strategy, Engineering, and Commercial Aviation Services and Supplier Management.

The ecoDemonstrator program also works with airline customers, suppliers and NASA and in support of the Federal Aviation Administration's CLEEN program, short for Continuous Lower Energy, Emissions and Noise. Felgar said the ecoDemonstrator program “motivates agencies like the FAA and NASA to actively seek technologies they could test on the ecoDemonstrator. The whole program draws everyone along on the timeline.”

Earlier this summer, the FAA CLEEN program completed flight testing of an engine exhaust nozzle made of ceramic matrix composites, developed by Boeing Research & Technology, on the ecoDemonstrator 787 Test Airplane. Ceramic matrix composites are designed to make engines quieter, lighter and more efficient. The CLEEN program is a competitively bid five-year program, with costs shared by participants.

“The nozzle is a great example of how we are working together within Boeing and externally with a government customer to accelerate the maturity of a technology that can benefit industry, airlines and the flying public,” said Craig Wilsey, Boeing's CLEEN program manager.

Both the FAA and NASA engage in research to advance the science of aerospace for public benefit. However, the application of government research to commercial products is industry's responsibility, Felgar said.

Teams are already at work installing equipment on the 2015 flying test bed, a leased 757 that will fly next summer with airline customer TUI Travel PLC, the largest tourism group in the world. Boeing is working with NASA on nanotechnology surface coatings to lower the accumulation of insect residue on the wing leading edge to reduce drag. In addition, Boeing and NASA are testing active flow control on the 757's vertical fin, which could result in the

design of a simpler, smaller structure to reduce weight and improve fuel use.

Other on-board technologies planned for 2015 include interiors made of more sustainable materials, lower-weight flight-deck components and fuel indicators, and high-speed data communications for more efficient flight. In addition, the next phase of testing will begin on a variable area fan nozzle that alters the geometry of the engine fan duct during flight, for reduced fuel consumption. The initial prototypes were flight-tested in 2012.

Loading multiple technologies onto each test flight saves time and money—and it energizes employees working in research and development, Akiyama said.

In some cases, engineers see their technology offered to the market within two years. That was the case for several technologies tested on the 2012 ecoDemonstrator that are now offered by Jeppesen, a Boeing subsidiary, for the general aviation market. Engineers always will rely on wind tunnels, simulations and analysis in the development of technology, Akiyama said, but there's no substitute for seeing everything work together on the airplane.

“The actual flight conditions—how the airplane operates as an integrated system, all the variables tested—it gets you there faster than analysis and wind-tunnel tests will,” Akiyama said.

It also reduces the risk of production and operational error.

“Moving quickly and learning faster means we identify production risks faster. Prototypes help us prove the technology before we introduce it,” Yu said. “It is about future generations—how do we leave aviation better than we came into it?” ■

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View a related video at boeing.com/frontiers/videos/september14.

PHOTO: The ecoDemonstrator 787 test airplane is silhouetted against a bright sky over Moses Lake in Eastern Washington during tests earlier this summer.