Extreme measures

The 787 Dreamliner has been tested to the extreme—and performed as expected in every situation

By Lori Gunter

The story of 787 flight test is largely a matter of perspective. Yes, the program has experienced many challenges. But it's also a story of perseverance and accomplishment.

"The challenges are real," said Scott Fancher, vice president and general manager the 787 program. "But so are the accomplishments. And at the end of the day, that's what the 787 program is all about.

"If we were intimidated by the challenges, we'd have thrown our hands up and walked away before we ever got to flight test," he said. "But that's not what we do. We work through the challenges with a focus on making this a great airplane. That ensures we do the right thing and that we keep moving forward."

Fancher acknowledged the 787 teamwork across the organization. "The program, Boeing Test & Evaluation and our partners are working hard to make sure we do the testing right and get good data," he said.

Since an onboard fire that halted flight testing in November, the team has developed hardware and software improvements that make the 787's power control system more robust. Interim fixes have been deployed on the flight-test airplanes, and one by one, they have re-entered flight test.

Within the same time span, a seventh airplane made its first flight and joined the flight-test fleet on a temporary basis.

By the end of January, the fleet had logged more than 2,600 hours of flying, nearly 900 flights and approximately 1 million miles (1.6 million kilometers). The team has pushed the 787 to prove that it is ready for the most extreme flight conditions it will ever experience in revenue service and many that it likely will never experience outside of testing.

The 787 has conducted testing in Iceland, Puerto Rico and Bolivia—demonstrating performance in high winds, and takeoff and landing performance at high- and low-field elevations. The team has been in the heat of the desert, the extreme cold of the McKinley Climatic Chamber at Eglin Air Force Base in Florida, and even conducted polar navigation tests at the North Pole.

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PHOTO: The 787 test-airplane fleet has made more than 200 flights since it returned to flight status in late 2010. BOEING

also a lot of work. The sheer logistics of getting the airplane and team to a new location, setting up our offices and coordinating our test flights with the local air traffic authorities is a huge job."

Perhaps the most difficult deployment concluded in February when the team on ZA005 returned from high-altitude testing in La Paz, Bolivia. The airport's 13,300-foot (4,050-meter) altitude meant the ground crew was operating with only 60 percent of the oxygen found at sea level.

"We started in Victorville, Calif., doing fuel consumption testing," Bryan said of the 24-day deployment for the high-altitude tests. "From there we went to Albuquerque, N.M., and performed takeoff tests at a mile-high airfield. The next stop was Puerto Rico for warm-weather takeoffs, and then on to La Paz."

In all cases, according to Mike Sinnett, 787 vice president and chief project engineer, the 787 has performed as expected.

Sinnett described one particularly challenging test that demonstrates the overall robustness of the 787 design and its capability to maintain safe conditions in the presence of multiple failures.

"We intentionally failed one of the three air-data systems that provide key information on speed and altitude," Sinnett explained. "After that, we caused the remaining two systems to disagree."

When the two remaining systems disagree, it means there is no known valid source of speed and altitude data. That's when the backup systems kick in.

"Pilots see an annotation that they are getting this information from backup systems, but they never lose data on the primary flight display," Sinnett continued.

Altitude is provided from the GPS system. Known conditions from a variety of systems and inputs, including aircraft gross weight, angle of attack, high-lift configuration and other parameters, allow the airplane to back-calculate airspeed from the lift equation and display it on the flight deck.

"This represents a significant advancement in safety and crew awareness in the presence of multiple failures," he said.

Compared with previous new-airplane programs, the 787 flight-test program has experienced fewer software problems. While flight test is not yet complete, the improvement is measurable; it is attributed to an increase in integration tools, laboratory capacity and ground-based testing.

The airplane's aerodynamic performance has been stable as well. Only two minor changes to the external aerodynamics have been made since the start of the flight-test program: Vortex generators have been added to the vertical fin to improver rudder effectiveness at high rudder deflection angles, and the in-board slat position has been tuned to address behavior in stall entry.

"Every program learns from what has happened before and makes its own advancements," Sinnett said. "It's part of what sets Boeing apart as an industry leader."

Because of the significant amount of new technology on the airplane, the 787 team decided to increase the laboratory testing that preceded flight testing. The team conducted about three times as much systems testing in integration labs than with the 777. Structural testing was even more robust.

The results have been noticeable.

Not only are there fewer flight-test problem reports, but fewer changes have been needed to the interface that controls the timing and flow of information between systems on the airplane. Such changes are both costly and time-consuming.

Sinnett said the program has seen a 90 percent reduction in those changes since the start of flight test, compared with Boeing's previous all-new airplane.

"That's significant and it's a tribute to the team that integrated the functions and tested the architecture so diligently before we ever got into flight test," he said.

Through last month, Boeing has completed more than 75 percent of the flight testing required to certify the first version of the 787 and retired the majority of the risk associated with flight testing.

Most of the remaining tests are to either demonstrate for the Federal Aviation Administration conditions that the 787 test planes have already flown, or to show how the 787 will behave in normal operating conditions, Sinnett said. Also remaining are extended operations tests known as ETOPS to certify the 787 to fly long transoceanic and transpolar routes.

The nature of flight testing, Sinnett pointed out, is to find issues—and solutions when possible.

"From very early on we've told people that testing is a dynamic environment, and while the risk is lower, we're realistic about the possibility of new discoveries," Sinnett said.

Fancher, the program's leader, noted that no one started working on the 787 "under the illusion that it would be easy.

"We have created an airplane that brings exceptional value to the market," he said. "And at the end of the day, everyone understands that safety is our first priority." ■

loretta.m.gunter@boeing.com

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PHOTOS: (Top) The first of the 787 test airplanes conducts extreme takeoff testing as part of the certification process. BOEING

(Left) La Paz, Bolivia, provided a unique environment to demonstrate the 787's takeoff and landing performance at high field elevations. RUBEN DARIO CUELLAR LORINI