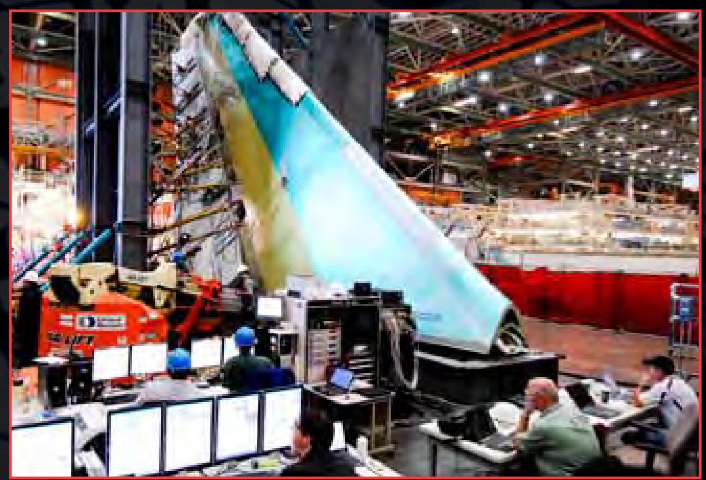

PHOTOS: **(Top)** As part of the F-15C full-scale fatigue test in St. Louis, the aircraft's wing is covered with tension pads bonded to the surface. BOB FERGUSON/BOEING **(Insets, from left)** In Everett, Wash., Dale Best prepares for the 747-8 Freighter rudder proof test, which simulates loads on the rudder surfaces; a Boeing Test & Evaluation team in Everett oversees the 747-8 Intercontinental rudder proof test. JEREMIAH SCOTT/BOEING

Outer *limits*

By testing to the extreme, and often beyond, structural engineers help ensure Boeing products are safe

By Jennifer Hawton

Boeing is known for having safe, durable products. So what does Liam Brett-Eiger do for the company?

"I'm a professional destroyer," quipped Brett-Eiger, a structural materials test engineer.

Brett-Eiger and 160-some Boeing Test & Evaluation structural test engineers may have a good sense of humor, but their work is serious business: They have a hand in making sure that all Boeing products can be operated safely.

The team pushes structures to their physical limits, finding out where the breaking point is—often with an audible pop, snap or crack. Their efforts help ensure the safety of Boeing jets by verifying that the breaking point lies exceptionally far away from what a pilot may experience, even in extreme circumstances.

"Our job is to make sure that passengers and crew can trust the airplane they're in," said Marshall Short, Lab Test Operations vice president. "We test—and sometimes break—things so people know they can trust our products."

"It's too bad the average traveler has no idea about all

“We push every piece of every product to its limits—and beyond—to ensure the products can easily handle any situation...”

– Michelle Fitzgerald, deputy capability leader for structural testing

the work these teams do to keep them safe,” he added.

Structural tests fall into two main categories: static and fatigue.

Static testing determines an airframe’s ability to carry loads. Loads applied during the final phase of static testing are 50 percent greater than loads that may be encountered in service. Photos and videos of static testing, with airplanes encased in large scaffold-like structures, show dramatic images of airplanes surviving seemingly impossible stresses, such as having their wings bent almost vertical.

Fatigue testing subjects airframes to the equivalent of up to three lifetimes of in-service wear and tear to help determine durability. This work also helps set operator maintenance and repair schedules.

Boeing was one of the early pioneers of full-scale static and fatigue testing, beginning in the 1920s. The basics behind these tests haven’t changed over the years, but the execution has—dramatically. For instance, data-collection techniques have advanced significantly since the company started structural testing.

Originally, there were several “deflection men” responsible for manually recording data points.

Today, Boeing static tests use a system that’s precise, sophisticated and the largest of its kind. Devices that capture any change in position to within .0025 of an inch allow more than 50 design engineers and stress analysts to remotely monitor airframe health, comparing their predictions to test data in real time.

The way loads are applied to the airframe has also evolved. Each structural test once required 29 employees, including 11 “pump men” who manually operated hydraulic controls to apply flight loads to a test article. Today, two engineers operate one computer that controls in excess of 150 servo-hydraulic load systems.

Recent Lean+ improvements to the 787 test program significantly shortened the test setup, according to Lee McNeil, 787 test setup lead engineer.

The upgrades included new ways to build full-scale static test structures, and using large-scale laser tools that can easily measure an entire structure at one time.

“Although the tools and instruments have advanced, our job still is as exciting as it ever was,” said Michelle Fitzgerald, deputy capability leader for structural testing. “We push every piece of every product to its limits—and beyond—to ensure the products can easily handle any situation they are likely to encounter.”

From verifying the usable life of a stowage bin to identifying ways to improve the safety of helicopters, the test teams have done it all in making sure Boeing products are safe—in and out of the sky.

“I don’t stress when I fly,” Fitzgerald added. “I’ve seen those wings bend 26 feet [8 meters]—I have supreme confidence in our products and I know that they will withstand anything they come across in flight.” ■

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PHOTO: A time-lapse photo of the 787 full-scale static test demonstrates how the jetliner’s wings withstand 150 percent of expected forces. The wings are bent to 20 feet (6 meters) at the maximum test load. JENNIFER REITZ/BOEING

PHOTO: An F-15C airframe is hoisted into the full-scale fatigue test fixture. On the ground are, from left, Jeff Crow, Dan Kretschmer, Phillip Jordan, Matthew Duncan and Catherine Mettlach. At the top are Andy Baugh, left, and Scott Teall. BOB FERGUSON/BOEING

For this structural engineer, the fun and excitement of work is in the variety of testing programs

After 32 years as a structural test engineer, Edward (Sam) Baker still gets excited when he talks about the different Boeing programs he's had a hand in testing.

These include International Space Station hardware, space shuttles, Delta rockets and the X-51 WaveRider.

His favorite?

Baker is hard-pressed to say, explaining that it's the variety of programs that makes the job exciting. But he finally signals out his support of the structural testing on the massive Delta IV rocket.

"Ever since watching Apollo launches as a kid, I've been interested in rockets," Baker said. "I've followed rocket programs ever since, so it was a thrill to be a part of that legacy."

Today, Baker, who's based in Huntington Beach, Calif., is involved in fatigue testing on a critical part of the B-1B bomber. But he also supports fatigue testing on the F-15C in St. Louis.

The B-1B testing provides the U.S. Air Force with critical data used to define aircraft maintenance and budget needs for the existing B-1B fleet. The fatigue testing Baker oversees is part of what is known as a "life extension program."

Baker's work takes place specifically on the dorsal longeron—a 40-foot-long (12-meter-long) component that essentially is the spine of the aircraft. The longeron starts at the cockpit and runs down the centerline of the fuselage, ending at the wingbox. The testing is done on an actual piece of hardware cut from a deactivated aircraft.

Fatigue testing helps simulate the cyclical stress that occurs on an aircraft during a lifetime of flight. Aircraft are stressed in many ways, such as during takeoff and landing or while making maneuvers. During this type of fatigue testing, data are gathered that provide a better understanding of how an aircraft and specific parts will age over time.

The work that Baker performs in St. Louis in support of the F-15C program is similar to what he's doing on the B-1B. But the entire F-15C is being subjected to fatigue testing, not just a part of it. As with the B-1B, the primary goal is to provide critical data to the customer on how an existing aircraft will react to various stress patterns.

Regardless of the program, Baker said, "it's really a team effort. You need a skilled team of the right size and with different skill sets in order to put together a successful test."

He also said the integration and consolidation of the company's widespread testing operations into one organization, Boeing Test & Evaluation, has created a "test community" that didn't exist before.

"There are cultural differences and it will take time to sort through those," he said, "but in the long run, integration will help us develop common systems and provide employees more opportunities."

– Suzi Hammond

PHOTO: Sam Baker examines F-15 structure load pads. BRUCE BECKER/BOEING

Structural testing around Boeing

On any given day, Boeing structural test labs are supporting testing requirements throughout the enterprise. Here is a snapshot of just some of the current structural testing being conducted around the company.

PUGET SOUND REGION

787-8 full-scale fatigue test
30-month test to simulate two lifetimes of airline service

B-1B full-scale wing test
Five-year test to simulate two extended lifetimes of service

P-8A Poseidon full-scale fatigue test
Currently preparing for the program to test two in-service lifetimes

CALIFORNIA

Commercial Crew Transportation System
Development and risk-reduction testing of selected structures and subsystems; supports future qualification testing of a commercial transport space vehicle for rendezvous with the International Space Station and the Bigelow Aerospace space station

United Launch Alliance
Structural qualification test for Delta IV common booster core metallic liquid oxygen skirt

747-8 Rudder Rig
Test bed for simulation of flight conditions in support of flight testing

MESA

Apache Block III
Currently working main-rotor driveshaft fatigue test, transmission tests and composite main rotor blades for this significant AH-64 Apache upgrade

F-18 hail impact
Ice ball impact testing simulates in-flight hail damage to help create more durable radome for F-18 Growler

ST. LOUIS

F-15E full-scale fatigue tests
Five-year program to extend the life of the product

P-8A component fatigue tests
Certifying service life for horizontal stabilizer and landing gear