Nice ice, baby

Icing Lab Tunnel helps design, validation process

By Sandy Angers

Ice builds up on an experimental wing section at the Boeing Research Aerodynamic Icing Tunnel, one of only seven icing tunnels in the world.

BOEING RESEARCH AERODYNAMIC ICING TUNNEL PHOTO

Inside a nondescript building just south of Seattle, the air temperature is below freezing, and the wind is blowing at nearly 300 miles per hour (483 kilometers per hour). There you'll find Boeing employees bundled in warm jackets, gloves and hats.

They're watching ice form.

The setting is the Boeing Research Aerodynamic Icing Tunnel, one of only seven icing tunnels in the world. Operated by Flight Operations, Test & Validation employees, the BRAIT is an essential tool in the product development and certification processes.

The tunnel, measuring 4 feet wide, 6 feet high and 20 feet long (1.2 meters by 1.8 meters by 6.1 meters), is the third largest in the world. It allows engineers and flight-test pilots to validate aerodynamic designs and the performance of the ice-protection systems in an efficient laboratory environment rather than in real-world conditions, which can be time consuming, hazardous and expensive.

"We help assure the safety of an airplane to fly in natural icing conditions," said Gene Cain, Boeing Technical Fellow and the tunnel designer. "And we provide this capability in a cost-effective manner."

Lab employees create ice on experimental wing sections by creating airflow through the tunnel at 250 knots (288 miles per hour/463 kilometers per hour), the typical speed at which commercial jets encounter icing. Test engineers then set the temperature in the tunnel between 32 and –22 degrees Fahrenheit (0 and -30 C). A cloud of water is created by an upwind spray array, and ice begins to form on a test surface within seconds.

After a typical 30- to 45-minute test, ice shapes several inches thick form on the representative wing section. These shapes represent the icy buildup that could occur during a worst-case in-flight scenario, such as when icing conditions are severe and the deicing system fails.

Using computing analysis of the ice shapes, as well as still photos and video, engineers extrapolate and replicate the ice shape for an entire wing. The artificial shape is then installed on a flight-test airplane for stability and control flight testing.

"We create the ice shapes in the BRAIT, which are then manufactured utilizing rapid prototyping techniques and installed on an airplane to demonstrate, through certification flight testing, that an airplane can fly safely with those shapes on the wings," said Cain.

Built in 1991 to support the then-brand-new 777, the BRAIT has helped Boeing dramatically reduce the cost and time involved in the certification process. Prior to the icing tunnel, test pilots spent 60 to 70 hours flying airplanes in natural icing conditions to satisfy certification requirements. Only a fraction of that time—eight hours—is needed today, thanks to the BRAIT.

"The value the tunnel gives Boeing is a significant return of investment dollars. With the tunnel we can do the work much cheaper and shorten the certification process. It adds up to a huge cost savings," Cain said.

The BRAIT design-and-build team's greatest moment of satisfaction came at the end of the certification process for the 777 ice protection system, Cain said.

"Just knowing that the successful testing in the BRAIT led to the certification of the system with minimal 'natural icing' flight test was a great achievement. That feeling of accomplishment still exists today as we continue to support Boeing airplane programs such as the P-8A Poseidon, V-22 and the 787," he said. ■

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Lab work

Engineering Technical Fellow Gene Cain (left) and mechanic Michael Myers examine ice formed during a test in the Boeing Research Aerodynamic Icing Tunnel.

ED TURNER PHOTO

Before a new airplane model is built, about 1,500 Flight Operations, Test & Validation employees thoroughly test and validate that the airplane design meets certification requirements and Boeing standards. Much of that work happens among more than 250 Boeing-owned laboratories in Washington state. Here's a look at a few of the Commercial Airplanes test labs:

Aerodynamic wind tunnels: BCA owns and operates three wind tunnels: the Boeing Research Aerodynamic Icing Tunnel (see story on Page 30); the Boeing Transonic Wind Tunnel (for high-speed models up to Mach 1.1); and the 9-x-9 Low Speed Propulsion Aero Wind Tunnel, which includes nacelle inlet performance and thrust reverser testing.

Noise labs: Several Seattle-area labs use sophisticated and sensitive recording instruments and microphone-array systems to measure cabin, ramp and flyover noise. Flyover noise certification testing at Glasgow, Mont., is supported by a mobile laboratory.

Propulsion lab: The Propulsion Laboratory, at Boeing Field in Seattle, can perform a wide range of activities: scale-model tests, FAA certification tests, fire extinguishing tests, full-scale engine test support, fuel flow–meter calibration and fuel system tests.

Structural Dynamics Lab: To evaluate the dynamic behavior of structures, the SDL performs component vibration tests and wind tunnel flutter-model and ground vibration tests, and provides real-time data-processing support of flight flutter tests conducted by Boeing flight-test organizations.

Integrated Airplane Systems Laboratories: Employees at the IASL in Seattle test avionics, flight controls, electrical, hydraulic, payload, propulsion and mechanical systems on the ground, individually and combined, allowing for a smoother transition to flight testing and service introduction. The IASL also contains six flight simulators with fully operational flight decks where pilots test simulated flight characteristics.

Structures Laboratories: The Structures Labs validate the design strength, damage-tolerance predictions and the minimum expected service life of airplanes. Boeing uses a building-block approach to these tests, starting with small parts and progressively scaling up to a fully assembled airplane. Loads applied during tests often are far greater than any load that may be encountered in flight, and can help determine how much growth remains in the structure for future derivative airplane models.

Metrology Laboratories: These labs calibrate, repair and maintain the company's measurement and test equipment. Employees measure a wide range of conditions and materials, including chemical, low-frequency and radio frequency/microwave, electromagnetic fields, optical radiation and physical and dimensional parameters.

When not being used to test and develop Boeing products, these laboratories are available for use by non-Boeing entities through Boeing Technology Services. BTS provides access to all Boeing test facilities throughout the United States. For more information, visit http://www.boeing.com/commercial/techsvcs/boeingtech/contact.html.

—Sandy Angers

BY THE NUMBERS: *Icing tunnel*

91 The number of test programs conducted for Boeing airplanes since the Icing tunnel's inception

7 The number of icing tunnels in the world

2 The number of icing tunnels larger than the Boeing Research Aerodynamic Icing Tunnel

6 The number of nationally recognized experts in the field of icing tunnel testing, including Boeing Technical Fellow Gene Cain