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Air Crash Investigators Focus on Carbon Fiber

Composites in Flight 587's Tail Fin May Hold Key to Finding Cause of New York Plane Disaster

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It took only a few seconds. Just after takeoff, American Airlines Flight 587 lurched twice to the right and once to the left. Suddenly its tail sheared off and the plane plunged out of control, crashing and killing all 260 people aboard.

Nearly a week after last Monday's accident, the National Transportation Safety Board has all but ruled out terrorism as its cause. Instead, investigators are looking at why the Airbus A300's carbon-fiber, reinforced composite vertical tail fin broke off—almost certainly the final casualty that doomed the aircraft.

The key question, several experts say, is whether the fin broke because a freak combination of torque and turbulence stressed it beyond anything envisioned by its designers, or whether fatigue had weakened the fin's fibers to the point where a bit of strong wrenching was all that was needed.

The distinction is important for both passengers and the airline industry. A one-of-a-kind event can be dismissed as a tragic rarity, but a fatigue-caused casualty would raise questions about the integrity of composite aircraft components, a relatively new phenomenon in commercial aviation.

Airbus, the Toulouse, France-based company that builds A300s, would not discuss Flight 587 because of the current investigation. But company officials described in detail a rigorous testing procedure—certified by the Federal Aviation Administration—for the composite tail fins, which have logged 35 million flight hours since they made their appearance in 1986.

Still, in the case of Flight 587, "it seems almost certain that the structures exceeded their design allowables, but what caused it?" said Duke University mechanical engineer Earl H. Dowell. "The critical question for the NTSB is whether the stress level was exceeded once, or whether it was exceeded repeatedly until it broke from fatigue. You can bet they're looking at that right now."

The full answer will not be known for months, if ever. Still, important facts have emerged in the investigation's early days. First, while the fin sheared off above the brackets at its base, neither the brackets nor the bolts anchoring them to the plane's aluminum fuselage appear to have failed. The joint itself survived; the break is in the composite above it.

Engineers said this could mean that fatigue had weakened the polymer above the brackets, but it could also mean that catastrophic stress had simply snapped the fin. It seemed to rule out festering corrosion at the composite-aluminum joint as the cause of the casualty.

Second, information from Flight 587's flight data recorder shows that the plane was twice buffeted by "wake turbulence" from a Japan Air Lines Boeing 747 that had taken off just before it, then veered sharply three times because of unexplained rudder movements. The rudder is anchored to the tail fin and moves left and right.

This means the plane was subjected to unusual stresses, but whether they could—or should—have been extraordinary enough to break the tail fin is unclear: "Were these loads beyond anything ever dreamed of?" said materials engineer James C. Williams, dean of engineering at Ohio State University. "It's hard to say. They [Airbus] estimate the maximum force under a worst case, then add a safety margin. There's no reason to think they've missed something."

The advantage of carbon-fiber, reinforced composites is that they are extraordinarily strong and stiff and weigh far less than aluminum. They were first developed by the U.S. Air Force and Navy and are created by laying strands of very long carbon graphite molecules in an epoxy matrix that is baked in an autoclave.

The composite had all kinds of uses—in products as diverse as golf clubs and vaulting poles—but "the magic was in its stiffness divided by its weight," said University of Delaware mechanical engineer Richard Wool. "It was ideal in aeronautical applications."

Not so ideal was the price. Graphite strands and epoxy are expensive, and the testing, analysis and quality control needed to produce material suitable for high-performance aircraft raise the cost of a composite component to several times that of its aluminum equivalent.

This high cost has slowed composites' entry into the commercial market: "In a military application you're willing to pay for performance, but it's not the same for a commercial airline," said Ohio State's Williams. "It's like the difference between a race horse and a draught horse."

Still, most commercial aircraft manufacturers have found composites increasingly attractive because less weight means lower fuel costs. And as time has passed, the industry and the world's regulatory agencies have developed testing protocols designed to ensure that composites will hold together over time.

That is a concern. For if composites are bumped, beaten or excessively shaken, they can develop microscopic cracks that, if allowed to fester, can widen and critically weaken the polymer.

Another concern is "delamination," in which heat, cold, humidity or manufacturing errors cause layers of the composite to separate.

Airbus has been using composite tail fins for 16 years, said Roland Thevenin, the company's certification specialist. The basic test procedure begins with the production of "sample" tail fins containing built-in delaminations and cracks.

The sample is put through the equivalent of 120,000 "cycles" of a takeoff and landing to test fatigue and damage tolerance. A "static test" measures composite strength at 1.5 times the maximum load the aircraft is expected to endure. Performance is measured at 70 percent humidity, and at minus 83 degrees Fahrenheit and 158 degrees Fahrenheit.

When this is finished, the tail fin will not need to be tested again. "If we don't have any [subsequent] visible damage, the structure should be okay for life," Thevenin said. "The typical check is a visual inspection, and if there is something visual, you have to look more closely."

Staff researcher Lynn Davis contributed to this report.

CLARIFICATION

A Nov. 16 Business section article was unclear about the nature of the terrorism coverage exclusions that Insurance Services Office Inc. is seeking from state regulators on behalf of 200 insurance groups. Those exclusions would involve only commercial policies and general liability war risk coverage.

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