

NASA Research Might Hold Key to Preventing Some Airline Crashes

Computer visualizations help scientists better understand engine failures from "blade-outs"

by Anna Turnage

An object as small as a hailstone has been known to cause catastrophic failures in jet engines. In some cases, hundreds of people have died when shrapnel created by a foreign object strikes a running jet engine.

It is this type of engine failure, called a blade-out, that some have speculated might have caused the tragic crash of a Concorde jet in France on July 25. A blade-out occurs when a fragment from one of the engine's blades breaks, shooting outward and damaging other vital parts of the plane.

Because engine blades spin as fast as 7,000 revolutions per minute, any outside object that is sucked into the engine can break off pieces of the blade. Broken pieces are shot out of the engine with incredible force, creating the potential for catastrophic damage.

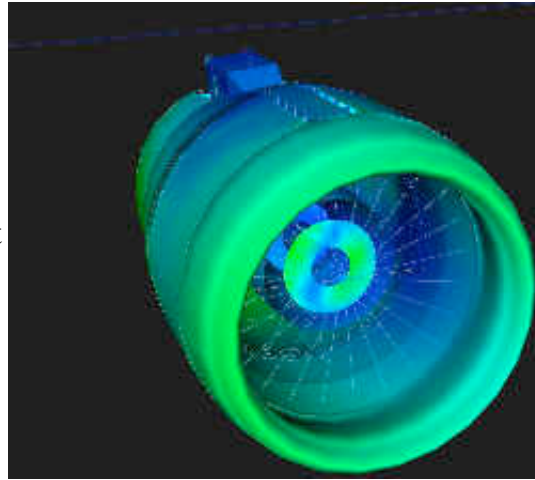
Although these types of engine failures are rare, they have been known to cause serious airline crashes. In 1989, for example, a United Airlines DC-10 crashed in Sioux City, Iowa, killing 112 passengers. Officials determined that a metal hub holding the engine's blades broke and ruptured the jet's hydraulic lines.

Blade-out Busters

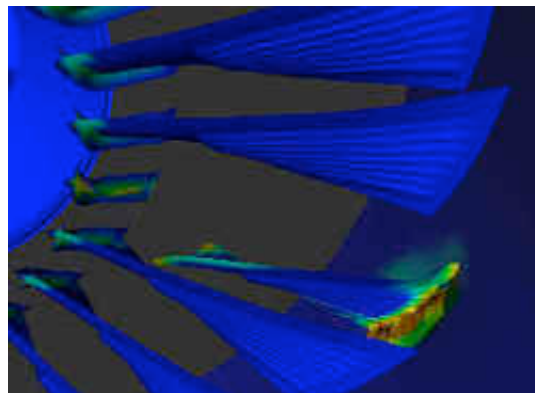
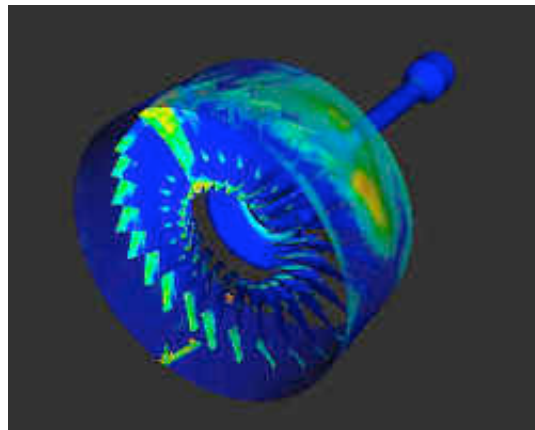
To help prevent or reduce the chances of this type of event occurring, scientists at NASA Glenn Research Center in Cleveland, Ohio, conduct research on blade-outs at the Ballistic Impact Facility. Glenn researchers use a 40-foot-long cannon to shoot metal blades against test plates. These physical test results are compared against computer models.

"The blade-out research is interesting in that it combines physical tests using a ballistic cannon (BANG) and sophisticated computer simulations," says Dorothy Carney, NASA visualization programmer for the project. Using EnSight software from CEI (Morrisville, N.C.), Carney can create animated 3D models of the tests, displaying the impact and force of a breaking blade in a jet engine.

"The simulations are generated in Livermore Software's LS-DYNA," Carney says. "EnSight allows us to display animated 3D models in stereo on an



A single view from a flipbook animation showing how the whole engine shakes when a blade is lost.



ImmersaDesk. This is a very dramatic platform, which gives us a better in-depth view of the data generated in our research."

A view of a full ring of blades on a hub and shaft. One blade breaks and is contained.

The LS-DYNA program produces models and simulations of physical events. Results from LS-DYNA can be read directly into EnSight for animated 3D visualizations that are used to analyze, visualize and communicate information. The ImmersaDesk is a single-display device with a large rear-projection screen that allows users to view models in stereo 3D. Researchers can manipulate the models on the screen with a hand-held wand. EnSight animations running on an ImmersaDesk add depth, detail and real-time interaction to NASA Glenn's simulation environment.

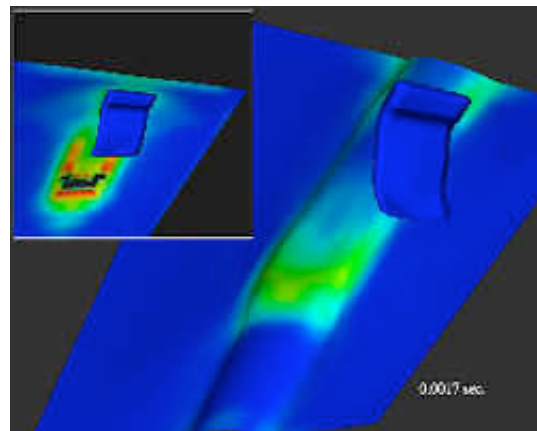
Positive Research Out of Tragedy

Although most jet engine containment cases are made of metals such as titanium, aluminum or steel, some manufacturers have begun to encase engine cores with lightweight, strong materials such as Kevlar, the same material used in bullet-proof vests.

Carney says NASA Glenn's blade-out research is also aimed at finding a stronger and lighter material for successful blade containment, one that will make the jet lighter and more fuel efficient. "The key goals of this research are to better understand blade-out events and to identify effective casing shapes and materials for optimal blade containment," she says.

Just because a blade fragment is contained, doesn't mean the problem is over, according to Dr. Kelly Carney, a NASA researcher with the blade-out project. The massive unbalance from the fragment still causes potentially destructive loads to be applied to the engine and the aircraft.

A government and industry consortium consisting of NASA Glenn Research Center, General Electric, Pratt & Whitney, and Boeing has been working to try to improve the prediction of this complicated event, Dr. Carney says. The group is using LS-DYNA to analyze the event and EnSight to visualize it.



Images from two tests: one with a flat-plate casing and one with a curved-plate casing. This is a simulation of real physical tests using the ballistic cannon.

Blade-out tests on real engines are a costly FAA requirement that engine manufacturers must perform. Researchers look forward to the day when computer simulations can completely replace these expensive tests. Meanwhile, their research is increasing our understanding of what could cause a potentially catastrophic event, and exploring ways to prevent it from happening.

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