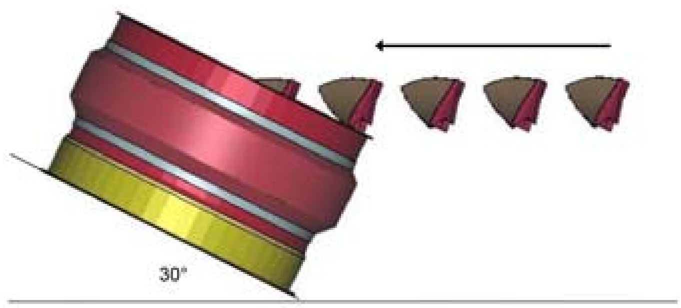
Damage-Tolerant, Affordable Composite Engine Cases Designed and Fabricated

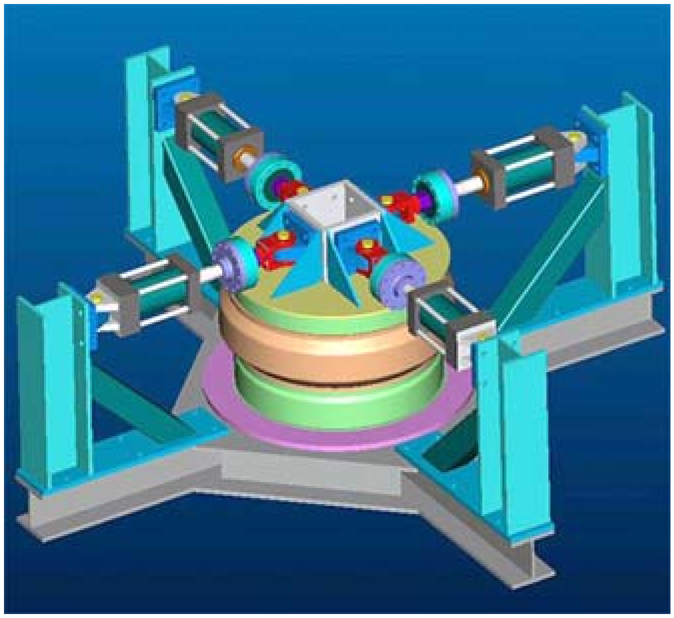
An integrated team of NASA personnel, Government contractors, industry partners, and university staff have developed an innovative new technology for commercial fan cases that will substantially influence the safety and efficiency of future turbine engines. This effective team, under the direction of the NASA Glenn Research Center and with the support of the Federal Aviation Administration, has matured a new class of carbon/polymer composites and demonstrated a 30- to 50-percent improvement in specific containment capacity (blade fragment kinetic energy/containment system weight). As the heaviest engine component, the engine case/containment system greatly affects both the safety and efficiency of aircraft engines. The ballistic impact research team has developed unique test facilities and methods for screening numerous candidate material systems to replace the traditional heavy, metallic engine cases. This research has culminated in the selection of a polymer matrix composite reinforced with triaxially braided carbon fibers and technology demonstration through the fabrication of prototype engine cases for three major commercial engine manufacturing companies.



Ballistic impact test configuration for full-scale composite case determined by computer simulation. Blade angle, impact location, and case inclination angle were selected to simulate blade dynamics in an engine blade-out test.

Long description of figure 1. Schematic of softwall fan case at a 30-degree inclination angle with the fan blade projectile headed for a representative impact location.

Affordable composite fan cases have been designed and fabricated for both hardwall and softwall containment strategies through sustained NASA Aviation Safety Program investment, leveraged Space Act Agreements and Small Business Innovation Research, and committed partnerships. In the hardwall design, the fan case must be thick enough to prevent penetration of blade fragments. In the softwall design, the inner layer of the fan case is penetrated and the blade fragments are caught by a layer of high-strength fabric, such as Kevlar (DuPont). In both designs, the engine case must maintain structural integrity after impact and withstand the rigorous loads imposed by an out-of-balance rotor. Sub-component-level tests of the prototype engine cases are planned by Glenn and the engine companies to assess both the impact response and the postimpact structural integrity. Evaluations are currently underway for side-by-side comparisons of full-scale prototype composite containment systems to conventional containment systems of existing engine products contributed by General Electric, Honeywell, and Williams International. Company projections show weight reductions of up to 50 percent with comparable or lower manufacturing costs.



Test cell for postimpact damage tolerance testing of engine fan cases and a production-quality metal/softwall case provided by an engine company.

Long description of figure 2. Test cell photograph showing a softwall metallic fan case that is representative of the state of the art in current fan containment. Hydraulic actuators are positioned at the inlet end of the case so that out-of-balance rotor overloads can be simulated.

The research at Glenn has been a multidisciplinary effort with personnel from Glenn’s Structural Mechanics and Dynamics, Polymers, Structural Analysis, Life Prediction, and Advanced Metallics branches. Other key partners in this program are General Electric, Honeywell, Williams International, A&P Technology, North Coast Tool & Machine, North Coast Composites, Cincinnati Testing Laboratory, the Ohio State University, the University of Akron, Ohio Aerospace Institute, and the Federal Aviation Administration. This research was part of the Jet Engine Containment Concepts and Blade-Out Simulation Team recognized with a 2004 NASA Turning Goals Into Reality Award.

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