NASAfacts

Damage Arresting Composites

Under NASA's Environmentally Responsible Aviation Project (ERA) the most promising vehicle concepts and technologies that can simultaneously reduce aircraft fuel use, community noise, and emissions are being evaluated.

Two key factors to accomplishing these goals are reducing structural weight and moving away from the traditional tube and wing aircraft configuration to a shape that has improved lift and less drag. The hybrid wing body (HWB) configuration produces more lift and less drag by smoothly joining the wings to the center fuselage section so it provides aerodynamic advantages. This shape, however, presents structural challenges with its pressurized, non-circular cabin subjected to aerodynamic flight loads. In the HWB, the structure of the center section where the passenger cabin would be located must support large in-plane loads as well as internal pressure on nearly-flat panels and right-angle joints. This structural arrangement does not lend itself to simple, efficient designs. Traditional aluminum and even state-of-the-art composites do not provide a solution to this challenge.

The solution which is being pursued under ERA in a partnership between NASA and the Boeing Company is a concept called the Pultruded Rod Stitched Efficient Unitized Structure (PRSEUS). While PRSEUS is uniquely suited to withstanding the in-plane loads, the bending loads, and the internal pressure loads typical to an HWB, it can also be applied to a traditional tube-and-wing aircraft.

Unique features of PRSEUS include using through-thickness stitches that enhance the adhesive joints between the stiffener flanges and the skin. This stitching (combined with the epoxy) removes the need for mechanical fasteners like rivets and bolts which are typically used to attach the stiffeners to the panel skin and provides a robust damage arrestment mechanism. Additionally, PRSEUS contains a pultruded carbon rod at the top of the stiffeners in the axial direction and has a tall, foam-filled frame in the lateral direction which contains a small slot for the rod-stiffener to pass through. Since PRSEUS parts are fabricated by stitching dry fabric layers together and then infusing with resin in an out-of-autoclave process, very large parts can be built without concern about the out-time limitations of epoxy or the size limitations of an autoclave.

Images **The hybrid wing body aircraft configuration which provides aerodynamic advantages compared to traditionally shaped aircraft; A 30-foot long** Pultruded Rod Stitched Efficient Unitized Structure **PRSEUS bulkhead panel;** A panel; Pultruded rod stiffener and foam-filled frame stiffener**; the completed multi-bay pressure box test article**

PRSEUS

A key to developing more fuel-efficient aircraft is to design and build lightweight primary structure such as the wings, fuselage and tail. This requirement leads to choosing composites, such as carbon epoxy, rather than the traditional aluminum, since composites are lighter than aluminum and offer more opportunities for tailoring the design to the specific loading environment for each part of the aircraft.

PRSEUS uses carbon composite layers of material in which the skin, tear straps, stiffeners, and caps are stitched together into very large panels with no fasteners. This through-thickness stitching eliminates the need for fasteners within panel acreage so fasteners are only needed at panel-to-panel connections. Using an out-of-autoclave process that requires only high temperature and vacuum pressure to infuse the resin into the panel, very large panels can be fabricated, further reducing the need for fasteners. Fewer fasteners means fewer holes to drill and parts to install, thereby reducing final assembly time. In addition, fewer holes mean fewer places where cracks could start and, therefore, fewer places that need to be inspected throughout the life of the airplane.

Additionally, conventional state-of-the-art composites tend to be brittle and can separate at layer interfaces, leading to the requirement for extra material and extra fasteners to prevent crack growth and separations between layers of material. PRSEUS' stitches have been shown to limit the type of crack growth and layer separation that can occur during aircraft service. This feature means that PRSEUS structures can be lighter than traditional composites while still meeting all safety requirements.

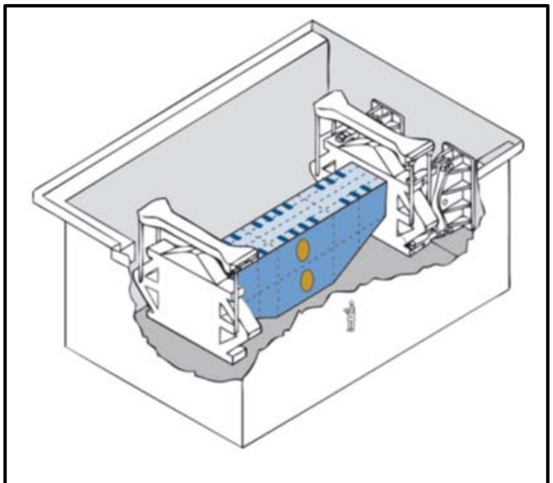

Image: **the mulitbay test article in the COLTS facility**

Multi-Bay Pressure Box

Throughout ERA and previous projects, a building block approach has been used to develop PRSEUS technology by studying small coupons, single-stiffener elements, and full-size panels. Tension, compression, and pressure loads have all been applied individually to test specimens to quantify their behavior. Test results have been compared to analytical predictions to verify our ability to accurately model each structure and prove that we understand its behavior.

The final step in this development project is a large-scale multi-bay pressure box test article which is representative of a heavily-loaded section of center portion of a HWB vehicle. This test article is approximately 80% scale of a possible future commercial transport aircraft.

The multi-bay pressure box is 30 feet long, 14 feet tall and 8 feet wide. Its outer pressure shell is made up of 11 PRSEUS panels. Four conventional sandwich panels make up the interior ribs and metal load-introduction hardware is included to mate the test article with the platens in the test facility.

The multi-bay pressure box will be tested in the Combined Load Test System (COLTS) at the NASA Langley Research Center. It will be subjected to a series of tests representative of flight conditions and FAA requirements for large commercial transport aircraft. The test article will be loaded to Design Ultimate Load in bending and internal pressure in 2015 to demonstrate that PRSEUS is a viable structural concept for commercial transport aircraft.

We're Working on...

"Green" airplane designs that will fly cleanly, quietly and very fuel efficiently

A new lightweight structural concept which will lead to more fuel-efficient tube-and-wing aircraft that can be easily adopted by aircraft manufacturers

The structural concepts needed to enable aerodynamically efficient configurations for aircraft of the future

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NASA Facts

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