# Fibre Composite Aircraft – Capability, Safety & Accident Response

*Russell Taylor (Australian Transport Safety Bureau)*

For many decades, fibre composites have been replacing traditional aluminium structures in a wide variety of aircraft types. From the first all-composite kit plane released in 1957, composites are widespread today in areas from cabin furnishings through to key structural members such as fuselages, wing boxes, control surfaces and empennages. This is due to the cost and weight savings that these materials offer aircraft manufacturers over aluminium, while maintaining or surpassing its strength and durability.

The purpose of this report was to provide an overview of fibre composite use in aircraft and the issues associated with its use, with a focus on aircraft operating in Australia that contain these materials. There are almost 2,000 aircraft on the Australian civil register made of, or containing, fibre composite materials. This includes most of the mainline jet fleet, effectively all sailplanes and gliders, many popular general aviation (GA) aircraft, and a third of the growing amateur-built aircraft category. Aircraft such as the Cirrus, Robinson R22/R44, Lancair and Jabiru ranges all contain significant composite structures.

Composites are formed from two materials – a reinforcing fibre which is woven into a ply, and a matrix material which bonds the plies together and provides the stiffness to shape the fibres into structures. Fibre composites used in aircraft generally are one of two types: carbon/epoxy which is used in major load-bearing structures, and glass/phenolic which is used in cabin furnishings and amateur-built aircraft structures. Plies of these materials are bonded together to form laminates, with the thickness of the laminate depending on the strength required for a particular structure.

Traditionally, aircraft structures have been made of metal, and hence there is a wealth of knowledge amongst regulators, investigators, maintainers and operators about the load capabilities, damage tolerance and reparability of these structures. In composite aircraft accidents, much less is known about how fibre composites behave under impact loads, how to identify failure modes, and what safety precautions must be taken by accident investigators when handling composites. The behaviour of these materials compared to equivalent metal structures was discussed when placed under tension, compression, bending and shear loads.

Impact behaviour of composite airframes was discussed, with a focus on delamination as it is the primary cause of failure. Common non-destructive techniques to identify delamination include tap testing, pulse echo and a range of ultrasonic methods. There have been several research efforts to test the survivability of composite airframes in a crash, and to measure the severity of subsurface damage that occurs. This includes the NASA AGATE program which simulated a hard surface impact of a Lancair Columbia 300 aircraft, and showed that while structures remained relatively intact after a crash, barely visible subsurface delamination and cracking can occur. Standard repair schemes for impact damage were highlighted, particularly non-patch repairs, bonded external repairs and scarf repairs. Programs to apply composite repair patches to fatigued metallic structures were trialled successfully in the 1980s and 1990s, with repairs requiring little maintenance or inspection over long periods of service time.

With the increase in the number of fibre composite flying in our skies likely to continue with the boom in amateur-built and very light jet (VLJ) aircraft, it is reasonable to assume that investigators will encounter these materials more often at accident sites. Composite structures pose new challenges for clean up crews and first responders, due to their flammability characteristics. While glass/phenolic composites have low flammability, carbon/epoxy and vinyl ester-based structures burn easily and produce thick, toxic smoke. Large amounts of carbon monoxide and dioxide can be produced in post-crash fires, and appropriate breathing apparatus must be worn. The safety risks of handling composite materials were explored, as fibrous debris is needle-sharp and can cause skin and eye irritation. More importantly, dust from some advanced fibre composites (such as E-glass) may have the potential to pose an inhalation threat similar to asbestos if handled improperly. In the event of a crash and post-impact fire, it is critically important for emergency services to evacuate passengers to a location upwind of the accident and away from fibre composite debris. Timely action will minimise passengers' exposure to these risks.

Typical first responders such as the police and fire services were contacted to find out what information or training, if any, they gave to make staff aware of the hazards of handling composite debris. This survey found that knowledge of composite hazards, and appropriate response methods are very disjointed between different emergency services in different states. The Australian Transport Safety Bureau (ATSB) provides materials such as the such as the Civil and Military Aircraft Accident Procedures for Police and Emergency Services Personnel to make this information more easily accessible to first responders, and to ensure their safety at aircraft accident sites.

It would be prudent for emergency services to review their aircraft accident response procedures, or develop specific procedures if they do not currently exist. Measures that could be implemented to do this include training workshops, incorporating ATSB accident response methods into Standard Operating Procedures, and development of 'first response' equipment and information kits for first responders.

A full report is available from the ATSB's website at [www.atsb.gov.au](http://www.atsb.gov.au).