HEAVYWEIGHT GOES LIGHT

Courtesy Boeing

Boeing's plans for the new 787 use more light weight composite materials than any civil aircraft ever built. Ahead of certification, safety specialists are focusing on structural integrity. John Mulcair & David Villiers report.

Boeing's revolutionary 787 is only a projected two years or so from entry to service, but scrutiny is intensifying of the greatest ever use of composite materials in a civil airliner.

Half of it will be made of various composites, and while Boeing is saying it isn't making public the non-destructive and destructive testing regimes for the 787 in its run-up to certification, safety regulators around the world are taking a keen interest.

Airframes specialists say the Airbus A380 is an evolutionary step beyond the Boeing 747, but consider the Boeing 787 perhaps an order of magnitude beyond the first widebody.

Technological experience gained, at great cost, by Boeing with its failed Sonic Cruiser concept in the 1990s has been re-directed and refined for the 787. It incorporates, in addition to the extensive use of composites, the electric architecture, improved computation, and engine advancements that started life as Sonic Cruiser developments.

Boeing has racked up an impressive 420 sales or other commitments for the airliner, the best ever for a commercial program, including up to 115 for Qantas and its Jetstar subsidiary. Variants of the new 787 will operate non-stop from Australia to all major Asian destinations and on to Europe, to the South Pacific and the US west coast.

The extensive use of weight saving composites, mainly in the fuselage, tail and wings, is a major part of Boeing's sales pitch claiming to deliver a 20 per cent fuel saving over conventionally built, similarly sized aircraft.

For the 787, these components are being made on a previously unknown scale – the world's largest autoclave has recently been completed for Vought Aircraft at Charleston, South Carolina, to make the fuselage barrel sections. After taking more than 18 months to build, it will process components to a maximum pressure of 10.2 Bar at a maximum temperature of 232 degrees Celsius.

Manufacturing staff must take extreme care to ensure there are no gases trapped between layers, as these can become failure points – which is where Boeing struck a glitch with one of the first 10 huge composite fuselage sections that were made for testing.

Its working area of 9.26m by 23m, for a total vessel volume of more than 2,320 cubic metres, makes this the largest autoclave in the world. Fully loaded, it weighs more than 500 tonnes.

PRESSURE COOKER

Biggest baker: Built to handle the wings and fuselage sections of the 787, this facility at Charleston, South Carolina, is the largest autoclave in the world. The giant pressure cooker operates at up to 232 degrees celsius and 10.2 Bar to "bake" sheets of carbon fibre soaked with resin, turning out solid composite forms.

FIN STRINGERS

Laying it down: Fabrication of the first composite stringers the Composite Manufacturing Centre in Washington. A Bo machine to lay down composite tape.

Composites are made by baking sheets of carbon fibre that are soaked with a resin. These sheets are laid over a forming stool to the required shape, and baked under great heat and pressure in an autoclave to make the solid section. Manufacturing staff must take extreme care to ensure there are no gases trapped between layers, as these can become failure points – which is where Boeing struck a glitch with one of the first of 10 huge composite fuselage sections that were made for testing.

The first seven test barrels were made successfully, with build and finish quality improving each time. However, on the eighth, which was planned to support certification testing, trials of a different mandrel, or forming tool, and production process led to some quality problems. The finished barrel was deemed unacceptable due to excessive porosity, partly caused by trapped gas or air. The ninth barrel cured was acceptable from a quality and porosity point of view.

A team of experts determined the root cause of the issue with barrel eight was tool leakage; Boeing was moving forward in the certification process with the production of a ninth and 10th barrel with the previously proven production method.

CASA specialists are closely following the deliberations of the US Federal Aviation Administration (FAA), the European Aircraft Safety Authority and the International Maintenance Review Board as they assess the 787, and the performance of its composite structures.

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US military tests on composites show that they can shatter with few obvious early warning signs. In one military test, a 6kg ball was dropped from varying heights onto a section of composite reinforced with 25cm square, 2.5cm inch thick stiffeners. Initially there was no indication of damage, with the sound of the impact remaining constant and no visible sign of impact, but as the test continued, the sound altered, stiffeners shattered and the composite delaminated.

Reassurances are expected from Boeing that such problems have been overcome, along with details of systems showing how initial delaminations can be detected at an early stage, long before they become catastrophic.

Another area of interest to safety regulators is the reactions between the new composites structures and water. If moisture got into the composite matrix, it is possible that it could be drawn inwards along exposed fibres if protective laminations were compromised. As a result structures could be adversely affected by the expansion/contraction of the freeze and thaw cycle.

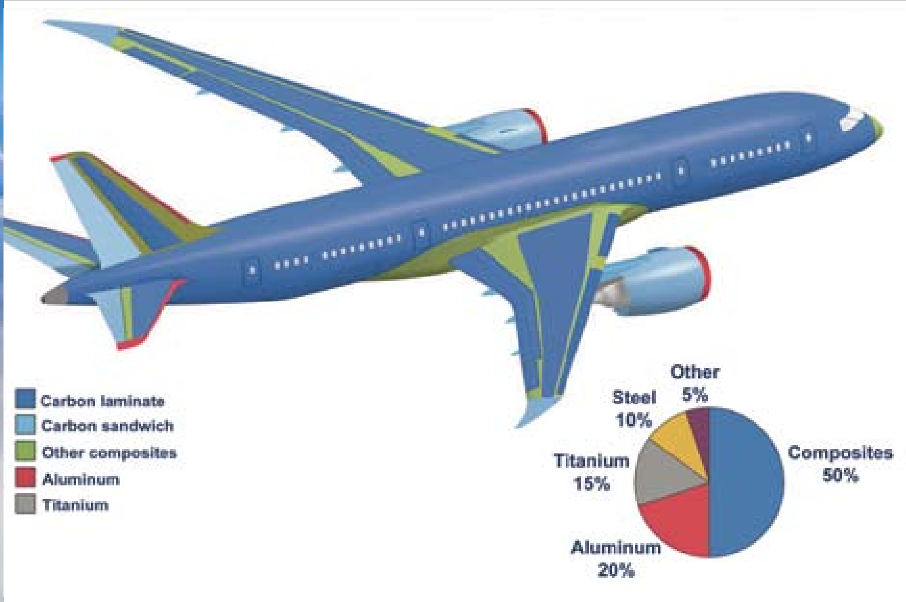
Conductivity following lightning strike is regarded by safety specialists as another matter for attention, with arcing and sparking across gaps causing great heat. There are safeguards, but composite airliners will be flying high, and will be taking large numbers of strikes during their work lives of at least 20 years and 20,000 cycles.

Damage surveillance: Nevertheless, specialists note that composites have proven their safety over many years in the military and in pressurised vessels. However, it is unlikely that requirements for damage surveillance on the ground would be relaxed.

Operators will need to ensure they have systems that encourage damage reporting from staff, including reports any significant impact to structures from cleaners, baggage handlers and other ramp staff. With composites you should not automatically be accepting

for the B787 vertical fin began in September at
eing technician operates the Centre's flat tape laminating

B787 COMPOSITE STRUCTURE



Primary material: Composites will form some 50 per cent of the primary structural material for the new Boeing 787 Dreamliner.

that if there is no mark that there is no damage to the airframe.

All aeroplane structures (metal or composite) are subject to routine inspection for accidental damage, environmental damage (corrosion) and fatigue damage, with the interval at which the structure is inspected determined by the acceptable exposure to the most likely type of damage.

Because composites do not corrode or fatigue, the inspection of composite structures is often determined by the acceptable length of exposure to accidental damage (metal structure inspection intervals are almost always driven by the acceptable exposure to damage from environmental and fatigue related causes).

The 787 composite structure would require periodic visual inspection, possibly less frequently than the aircraft types it is replacing. Boeing says that the 787 structure has been sized to account for the strength loss that could be caused by less significant damage which may be undetected in a visual inspection.

Boeing has demonstrated by analysis and testing that these small, hidden damages do not grow over time, and expects that 787 operators will be able to leave these damages undetected and unrepaired for the life of the airplane.

This is the same criterion and maintenance practice that is already approved for the composite structure on the 777. For larger damages which are detectable visually, Boeing may specify a form of NDI inspection such as pulse echo to fully assess the damage.

> Airbus Industrie ... will study development of structural health monitoring technology specifically to check damage to carbon fibre reinforced composite structures.

Airbus responds: Airbus Industrie has moved more conservatively into large-scale use of composites, but with the need to offer an airliner to compete with the Boeing 787 series and beyond, it has signalled its intentions with a research and development agreement with Japan's Institute of Metal and Composites for Future Industries.

They will study development of structural health monitoring technology specifically to check damage to carbon fibre reinforced composite structures. Airbus Industrie says the technology detects invisible strain or cracks through optical fibre used as sensors embedded in or bonded to the surface of composite structure aircraft.

It says the technology would immediately detect faults or abnormal transformations caused in the aircraft structure, even during flight, offering advantages such as improved safety and reliability or more efficient aircraft maintainability.

John Mulcair is a former News Ltd aviation writer; David Villiers is section head, airframes CASA.

BENEFITS OF COMPOSITES

- The ability to produce designs with larger, more integrated structures because of the way composites are manufactured.
- Significantly less waste during building, with fewer hazardous materials and shorter span times.
- A more durable structure that does not corrode or fatigue like metals.
- The ability to provide passengers with a lower cabin altitude and high humidity levels.
- Higher resistance to burn through in the event of a fire.
- Lower cost because of fewer repairs and lower landing fees (which are often based on weight).