



Composites consolidate in commercial aviation

FEATURE

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Carbon composite has well and truly joined the mainstream of aerospace construction, not least in the commercial aviation sector. Here, aircraft that are up to 50% by weight carbon are proving their worth as fuel-efficient carriers, polluting less and saving their operators money compared with previous-generation metal types. Below, we offer a round-up of progress made by some of the most significant drivers of the reinforced plastic aircraft revolution.

Right in the vanguard has been Boeing with its **B787 Dreamliner**. Despite a difficult gestation and birth, covered in earlier issues of *Reinforced Plastics*, this widebody people carrier has been pleasing occupants with its speed and comfort, and operators with its economical performance. The latter is largely due to the aircraft's ultra-light half-plastic structure.

Boeing has taken a pioneering role in extending the aerostuctural reach of carbon composite by adopting it for the aircraft's fuselage. Previously, in terms of commercial jets, carbon had variously claimed the wings, tail cone and empennage, control surfaces, internal pressure bulkheads, engine nacelles and various fairings, but stopped short at the fuselage, the central and most critical structure of an aircraft due to its role in containing the passengers and enclosing them in a life-maintaining pressurized environment. Boeing boldly broke the impasse by adopting carbon for the fuselage as well, thereby making the B787 one of the lightest aircraft for its size and capacity (nearly 300 passengers on the -9 variant). The fuselage, made up of tape-wound barrel sections, is the most revolutionary aspect and the first for a commercial airliner.

It so happened that Boeing's big European rival, Airbus, was in parallel developing a 50% carbon passenger jet for which it, too, was adopting a carbon-epoxy composite fuselage. This was for its A350 XWB, a widebody family of three, the largest being the A350-1000 with a 350 passenger capacity. But Boeing was first off the blocks, its contender achieving a maiden flight in December 2009, followed by entry into service with launch customer All Nippon Airways (ANA) in late 2011.

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By now the B787 has flown more than 100,000 revenue flights with 35 scheduled carriers, a figure that should rise to 40 by the end of this year. Nearly 400 Dreamliners are plying some 600 routes, almost two thirds of those being inter-continental. Many of the delivered jets are replacing other widebody types, thanks to the 787's superior operating economics. For example ANA has reported that the B787 burns 21% less fuel than the B767s it previously used on long-haul routes, and 17% on short-haul.

Among operators now equipped with the type are fast-growing Norwegian, which has taken advantage of the twinjet's highly competitive operating costs to launch affordable long-haul services, along with Qatar Airways, Air India and United Airlines which, likewise, have inaugurated new routes. Early teething troubles that inevitably accompany the introduction of any new aircraft type into revenue service appear to have been overcome and, in the main, dispatch reliability is now approaching anticipated levels.

Meanwhile **Airbus**, with its **A350 XWB**, has adopted a more conservative structural approach than Boeing for its carbon composite fuselage. Whereas the major 'barrel' sections of the Dreamliner fuselage are monolithic structures tape-wound in largely automated facilities, Airbus has based its solution on large composite panels attached to composite frames. This means that, at least in theory, A350 fuselage repairs can be made by removing just the panels affected, for subsequent attention in dedicated composite shops. This compares with having to repair B787 fuselage damage either *in situ* at an airport, as happened when an Ethiopian Airlines example suffered a major fire while on the ground at London's Heathrow Airport in 2013, or after removing the entire aircraft to a suitable facility. The A350



FIGURE 1

The Airbus A350XWB is extensively composite, including the empennage and vertical stabilizer, seen here (Image courtesy of master films/P. Masclet).

fuselage also has a slightly different shape, being more ovoid than spherical so as to confer the extra wide body (hence XWB) that enables the interior to accommodate 10-abreast seating if required (Fig. 1).

A350XWB first flew in June 2013 and five prototypes were used in an intensive flight test program that led to certification by the European Aviation Safety Agency (EASA) in September 2014 and by the Federal Aviation Agency (FAA) two months later. The type entered service with launch customer Qatar Airways, which has ordered 80 A350s, in January 2015. By May this year, orders for the A350 exceeded 800 from 42 operators, a recent order for six -900s from Philippine Airlines bringing the precise total to 802. Airbus has delivered a couple of dozen A350-900s while first flight of the largest variant, the A350-1000, is expected this July.

A production rate of up to 10 per month by 2018 is targeted, up from three or four per month being achieved currently (at time of writing). High-rate production has been facilitated by investment in new or up-graded composite production facilities including a £570 m unit in Broughton, Wales, for producing the wings and a new composite rudder plant in China.

End of a duopoly?

The most intriguing recent development in the airliner market is the entry of Canada's **Bombardier Aerospace** with its **CSeries** short-to-medium hauler, which promises not only to fill a gap at the sub-150 seat end of the narrowbody capacity range, but in subsequent variants to become a credible competitor to the smaller members of the Airbus A320 and Boeing B737 families that dominate air travel today. It could disturb the present duopoly of Airbus and Boeing, which between them have a backlog of some 12,000 aircraft on order, by adding a third aircraft supply leg.

Composites are playing their part in securing a low structure weight for the CSeries with reinforced plastic wings, tailplane, control surfaces and other primary elements. Wings are manufactured in Belfast, Northern Ireland, using a resin transfer infusion process. Bombardier already had considerable composites experience, having developed the predominantly composite Learjet 85 business jet, although this project was shelved in order to release funds for on-going CSeries development (Fig. 2).



FIGURE 2

Bombardier's CSeries has reinforced plastic wings, tailplane, control surfaces and other primary elements (Image courtesy of Shutterstock).

However, Bombardier limited development risk by selecting the low-weight metal aluminum–lithium for its fuselage, rather than carbon composite as first planned. Al–Li is an established competitor to composite and can, as the Canadian airframer likes to point out, be fabricated and repaired using metal forming techniques that are familiar throughout the global supply chain.

Much of the 10% fuel efficiency hike promised by Bombardier for its new twinjet is due to a bold choice of a radical new engine in which, thanks to the introduction of a geared reduction stage, the engine's front-end fan and compressor rotate at individually optimum speeds rather than at the same speed. The resulting improved engine architecture enables engine maker Pratt & Whitney to claim large fuel efficiency improvements for its Pure Power 1000G series compared with engines currently in service. Such substantial economies still interest airframers and operators even at a time when fuel prices have dropped dramatically from their peak of a few years ago, because of the competitive advantage conferred. Consequently P&W has clocked over 7000 orders for its geared turbofan engines, which have also been chosen to power Airbus A320neo (new engine option) aircraft plus Embraer E-Jet, Irkut MC-21 and Mitsubishi MRJ regional jet models.

The maiden flight of a CSeries aircraft took place in September 2013 and flight test results described as encouraging followed. Type certification by Transport Canada was achieved by the end of 2015. Despite a slow start as would-be operators waited to see how the extensively composite and GTF (geared turbofan) powered twinjet would fare in flight tests and early service, orders are now gaining momentum.

Lufthansa subsidiary Swiss International Airlines, launch operator for the smaller CS100 variant, has 30 aircraft on order plus 10 options (at least 15 of its aircraft will be the larger, 130-seat, variant) and is commencing service with its first 125-seat CS100 about now (June/July). Latvian carrier air Baltic is launch customer for the CS300 model and has 20 of the jets on order. Other orders from Air Canada (45 CS300s plus 30 options) and Delta Airlines (75 CS100s plus options for 50 more) have resulted in orders and letters of intent for over 300 aircraft, with approximately 250 more in the pipeline.

National virility

With a thriving aerospace industry being taken as a sign of national virility, it is no surprise that countries like Russia, Japan and China aspire to develop and produce aircraft that can achieve success in export as well as home markets.

Russia, for instance, for long an accomplished aircraft builder, has high hopes for the **Irkut MC-21** and Superjet 100 types produced by a rationalized aircraft industry. Irkut's mid-range

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