COMMON WING HOLDS KEY TO A330/A340

The A340 wing is virtually identical to that of the A330. Its design represents a rare, if not unique, achievement among commercial jet airliners — a wing which can support either two or four engines. Airbus claims this is not simply a good engineering compromise, but also an aerodynamic match that meets the economic cruise requirements of both the medium-range A330 and the long-range A340.

The A340 wing is the biggest to be designed and built by British Aerospace for the Airbus family. It has the highest sweep of any Airbus wing, to accommodate the higher, Mach 0.82-0.84, speed of the long-range aircraft compared to its predecessors which cruise at M0.80. At 30°, sweepback is still moderate compared with the Boeing 747’s 40° and the McDonnell Douglas MD-11’s 36°.

Although the A340 wing has virtually the same span as that of the 747-200, it has only 65% of the area, a high-aspect ratio having been chosen to cut both take-off and cruise drag. Span over the winglets is 60.2m and wing area is 362m² (compared to the A300-600’s 260m²).

The multi-role wing’s secret lies in the neat balance of bending moments (exerted on the fuselage by the wing) between the twin and four-engined versions. The A330 and A340 wing bending moments are within 1.5% of each other, allowing the two structures to be assembled in the same jigs.

Because of bending relief from the weight of its outboard engines, the bending moment of a four-engined aircraft is substantially lower than it is for a twin at the same maximum take-off weight. For the same fuselage weight, therefore, a twin needs a stronger, heavier wing than a quad.

It follows that, for the same wing, the payload carried in the fuselage must be less for a twin than a four, which is exactly what has happened with the A330/A340: the latter carries about 20% more payload. This translates to about 30t of extra fuel, giving the A340 its long-range capability and requiring the addition of a centre-fuselage undercarriage leg. Design strength required was “only” 1% higher than the A330”, says Jeff Jupp, BAe chief engineer, Airbus.

The wing betrays its A300 structural heritage with a load-carrying wing torsion box made up of front and rear spars linked by transverse ribs which support the top and bottom covers. Another feature of the A300 wing, an inboard centre spar, has been revived to help support the sheer size of the structure and to accommodate the more stringent needs for damage tolerance.

The centre spar terminates outboard of the inboard engine pylon.

Although similar in overall arrangement to that on other Airbus aircraft, the layout of leading-edge slats, trailing-edge flaps, spoilers and ailerons differs in detail — mainly because of the engines. Following a change from long slat segments to more, shorter segments on the A320 (for tighter rigging under load), the same approach has been followed on the A330/A340 wing.

The wing has seven slats per side with a gap between the fourth and fifth to accommodate the outboard engine pylon and, for the A330, a gap between the first and second for the inboard engine. Airbus estimates that the improved conformity of the slats will eliminate parasitic drag.

Other changes in control surfaces are evident in the two-section ailerons. Using the fly-by-wire, flight-control system, the ailerons are drooped for take-off and landing to provide a full-span trailing-edge flap. The ailerons are also deflected upwards after touchdown to increase lift dumping and braking efficiency.

As well as being used for roll control, the ailerons deflect upwards when the inboard airbrace panels are deployed during manoeuvres to relieve wing bending moments. The A340 does not have an A320-style gust-load alleviation system, says Jupp. “This wing is much more manoeuvre-dominated...the speed with which the surface needs to react is that much slower than the A320.”

Aerodynamically, the wing is a direct cousin of the A310’s and features the same three-dimensional design, adjusted for the longer-range missions. Aspect ratio is higher, at 9.3 against 8.8, and the wingtip devices, canted at around 45°, were included from the start of wing design, saving an estimated 1.5% on cruise fuel burn. The Hawker de Havilland-built devices deflect inboard at the tip by 5° in the cruise.

The most obvious visual difference between the A330 and A340 wings is the latter’s outer engine installation. “We already knew how to put engines on the inner wing position, but it took us two years to find out how to do it perfectly with the outboard engines,” says Airbus A330/A340 chief engineer Geoffrey Thomas. “We started off with the best ideals...which were to satisfy industrial demands by having common inner and outer pylons.” The inboard pylons were already at the same locations as those of the A330, which were reinforced for the engines of the twin.

Aerodynamic studies showed that there would be an aerodynamic penalty if all four pylons were the same. “The A330 pylons would have pushed the engine too far forward,” says Jupp, who adds that the new inboard pylon pushes the engine 400mm forward to preserve the aerodynamics of the “crucial gulley” between nacelle and lower wing skin near the wing root.

Two years of intense three-dimensional computer analysis, coupled with windtunnel studies, has resulted in the A340 having less wing/engine interference drag than the twin-engined A310, Airbus says.

To meet damage tolerance requirements, the fuel system layout is altered to keep collector cells (the aircraft’s final fuel reserve area) out of the potential strike paths of debris from exploding engines. Collector cells are placed midway between the inboard engine pylon and fuselage, aft of the inboard engine exhaust and forward of the outboard engine’s compressor line.