The advent of a new industrial revolution and the Airbus A350 wing

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A new industrial revolution is under way as composite materials increasingly replace traditional metals in engineering applications ranging from automotive to marine and construction to aerospace. The attraction is the increase in both strength and stiffness to weight ratios offered by composite or "non-metallic" materials.

Composites are produced from two or more materials, a "reinforcement" material brings the strength and stiffness to the composite, while the resin binds the reinforcement and transfers loads and often protects it from abrasion and impact.

This brings direct benefits in the form of: high strength to weight ratio; high stiffness to weight ratio; corrosion resistant materials; and impact resistant materials. These bring other indirect benefits by decreasing weight, for example, which increases fuel efficiency that has the potential to reduce running costs and aircraft noise.

Fibre reinforced composites were invented in the UK several decades ago. It would therefore be a regrettable industrial own-goal not to seize this opportunity to move into the "composite manufacturing age". Airbus' newest aircraft model, the A350, represents that opportunity.

Technology and innovation, as well as a market-led approach, are the foundation of Airbus' success as a European aircraft manufacturer, resulting in its current position as the world's leading aircraft manufacturer. Airbus, since its creation over 30 years ago, has been progressively increasing the ratio of composite materials in each new aircraft model, whilst gaining direct operational experience. It has also played a key role in the research and development of these materials.

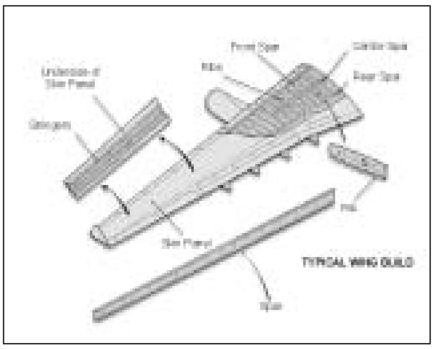
As Airbus' Centre of Excellence for wing design and manufacture, Britain, through Airbus UK, has studied the application of composites to wing technology and invested substantially in this field. The DTI supported R&D programmes since the mid 1990s involving many other British companies and specialist bodies that have provided advances and several "demonstrators". These include the study of structural properties and development of low-cost manufacturing and assembly of increasingly larger components. This led to the opening, earlier this year, of the Composite Structures Development Centre at Airbus UK's site in Filton, Bristol, which forms part of the UK's National Composites Network. The centre also provides capacity for use by other industries.

Airbus is preparing to introduce the new A350, available in two versions, for entry into service in 2010 in response to a demand from its customers for a new aircraft with more range and more seats than its successful and popular A330. The A350-800 will have a range of 8,800 nautical miles, typically seating 253 passengers in three classes and the A350-900 has a range of 7,500 nautical miles, seating 300 passengers, providing the efficiency and economic benefits airlines expect from Airbus. Flight deck commonality brings the crew training and operational efficiency of Cross Crew Qualification (CCQ) and Mixed Fleet Flying (MFF) and the aircraft will have significant spares and maintenance commonality with the A330, whilst new systems will bring more savings in maintenance costs.

The A350 has surpassed expectations since marketing commenced some nine months ago, having already achieved commitments for 130 aircraft from eight customers. With A350 in its product range Airbus expects to win half of the market for 3,000 aircraft in the 250-300 seat aircraft category during the next 20 years. The A350 has 13 per cent more seats, more range, lower fuel burn per seat and lower Cash Operating Costs per seat than its competitor, Boeing's new 787. Early orders received by Airbus have reinforced the company's approach for long range aircraft for the future.

Airbus has been refining the design of the A350 since the start of this year and the aircraft will have 90 per cent new part numbers and 60 per cent of the structure will be of advanced materials, including composites, and third-generation aluminium lithium.

The A350 will be the first Airbus commercial airliner to have composite wings, marking a turning point from metals to composites. This is significant for Britain, the



Typical wing build

home of Airbus wing design and manufacture. Carbon fibre reinforced plastic (CFRP) will replace traditional aluminium alloy for the spars and upper and lower surface covers of the wings for the first time. This is a step forward in the application of composites to wings, where composites have previously been used mainly on the leading and trailing edges, with that application extended on the A380 where some of the ribs are of carbon fibre.

The A350 wings represent a springboard for accelerated development of new skills, techniques and expertise in composites and the application of many years of research and development work. The composite components will be made up of several layers of lamina plies with each ply orientated in a particular direction to give a structure optimised for strength, weight and stiffness. "Laying up" is performed with an automated tape layer, requiring minimal manual intervention whilst using unidirectional fibre impregnated with epoxy resin in a "soft" un-cured condition.

When the lay-up is complete the component is cured in an autoclave using heat and pressure to produce a "hard" component. This process ensures that each ply is consolidated to produce a monolithic structure during the curing process. The component is then ultrasonically tested using a non-destructive test (NDT) that checks for flaws within the laminate. Some limited machining is then performed, if necessary, to trim the component to size and at interfaces with other components, so ensuring appropriate tolerances are achieved when the parts are assembled.

For the A350, each upper and lower cover will be manufactured as a single piece laminate with a span of 30 metres and a chord of six metres at its widest point. This will be the largest single composite structure ever manufactured for a commercial aircraft and provide the lightest solution. The technology selected will use a two stage curing process due to the size of the component and to overcome the complexities of the wing surfaces that have double curvature. The first stage will produce a "hard" skin upon which stringers in a "soft" condition are then positioned. The second stage will cure the stringers to the skin in a process called co-bonding.

Each spar is C-section in shape and will be attached to the upper and lower covers using fasteners. The front spar is a single component with a 30 metre span from wing-box rib one to rib 39 and will taper from 1500mm at the root to 200mm at the tip of the wing.

The maximum takeoff weight (MTOW) for the aircraft will be 245 tonnes. This induces high loads in the Main Landing Gear (MLG) support structure in the wings; distributing the MLG loads into the covers and inner rear spar. Research and design trade-off studies have shown that when subjected to high input loads, metal structures currently offer the best solutions in these areas.

The wing also acts as a fuel tank and the mass of the fuel acting downwards offsets the air-loads acting upwards. This simple law of physics results in a complex trade between aircraft weight and lift for various points in the flight from take-off to cruise and landing. The A350 tank arrangement is optimised for the composite wing with a new wing fuel tank arrangement. This will consist of a tip-to-tip simple three tank arrangement, compared to the five tank arrangement on the A330.

The new wing is being investigated using extensive aerodynamic testing in a wind tunnel. This includes shaping the wing surfaces to optimise aerodynamic performance resulting in fuel-saving, which together with close-coupled GEnx engines and a wing droop nose device, similar to that used on the A380, will enhance performance and help to reduce the aircraft's noise footprint. In Britain the low-speed wind tunnel tests are conducted at Airbus UK in Filton near Bristol. The high-speed wind tunnel tests are conducted at ARA in Bedford.

A350 Wind Tunnel Testing at Filton

The aircraft surfaces are optimised to cruise at Mach number 0.82 with flexibility to fly up to Mach number 0.85. This is achieved by introducing a new winglet and some re-profiling of wing surfaces, including a leading edge extension (LEX) combined with the droop nose inboard of the engine pylon. Whilst the droop nose was introduced to improve lift, the droop nose and LEX also decrease high-speed drag and reduce the fuel burn penalty from increasing the Mach cruise speed.

The A350 will create 10,800 jobs in the UK aerospace sector and a further 21,600 jobs in the wider economy from induced employment, with Britain playing a full and important role in the programme. As more composites replace metal in future aircraft and the application of composites increases elsewhere, the A350 wing represents a vital step forward in the development of composite industrial technology in Britain.