

100 Years in the Making

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2010 marked the 100th anniversary of the Bristol Aeroplane Company which was founded on the 19 February 1910 by Sir George White. To celebrate the Anniversary, a team of engineers from Rolls-Royce, Airbus and GKN set about the challenge of building a full scale replica of one of the Bristol Aeroplane Company's more famous aircraft, a World War I Bristol F.2b Fighter.

The main requirements of the project, which started in late 2009, were that the replica was to be visually representative of an original when viewed from 30 feet and be easy to disassemble and re-assemble to allow for transportation and display at various locations. In addition to this, and by far the most challenging requirement, it had to be ready for display at the Rolls-Royce Families day on the 3rd of July 2010.

Initial work focused on understanding the fundamentals of the original F.2b design (collating drawings, photos etc), agreeing how work would be distributed, planning required activities and obtaining a suitable budget. This work continued to the end of 2009 leaving only six months to complete the detailed design, manufacture and assembly.

Identifying data to support the design and manufacture proved difficult at first, only a handful of F2B's have survived despite thousands being produced. Organisations and individuals from as far away as the USA and New Zealand provided a range of information to help get the project started. Thomas Johnson of the Great War Replica Aircraft in the USA was a source of invaluable technical information from the start of the project. He was in the process of building a full size, flight worthy, F.2b replica to his own design and agreed to allow the project to utilise his design supplying a full set of plans as well as his experience of the F.2b. The information was extremely useful although the project chose not to utilise his construction methods, primarily because the replica was to be used for display purposes only and not for flight. Another significant source of information (and a little closer to home) was the Shuttleworth Collection who own an original flight worthy F.2b (D8096) which they allowed us to inspect and photograph in detail. More importantly they had approximately 4000 original drawings which they allowed us to borrow and reproduce. Even with all this information a significant amount of design work had to be conducted, primarily to simplify the design in order to meet the tight timescales. Despite the large number of original drawings there, was a lot of missing information (a full set would probably have been around 16,000 drawings), and the drawings covered a range of variants from 1916 through to the 1930s. Using the original drawings as a guide, a full 3D CAD model was produced, this 'virtual assembly' supported creating a full suite of manufacturing drawings and allowed many potential assembly problems to be identified and resolved prior to starting manufacture. The 3D CAD data was also used to support modern stress analysis techniques to ensure that the finished item could cope with unexpected loads such as a gust of wind.

In addition to basic design and manufacture, aesthetics such as the colours and markings were critical in ensuring a realistic finished product. It was decided to base the replica on a genuine WW1 aircraft, A-7288. This Aircraft flew many successful missions in World War 1 manned by F.2b Aces Andrew McKeever and Bristol-born Leslie Archibald Powell, one of the Fighter's most successful gunners.

A combination of some of aerospace engineering's oldest and newest technologies were utilised in the manufacture of the replica. Traditional methods such as fabric covering, woodworking and sheet metal work were combined with modern rapid prototyping techniques like stereo lithography to produce all the parts required. Modern technology was a necessity when it came to the manufacture of the replica engine. Despite the Falcon engine being originally designed and manufactured by Rolls-Royce no original drawings could be found. Only eight surviving engines were identified in the world, by chance one of these was owned by the Rolls-Royce Heritage Trust in Derby. Parts from this engine were scanned to produce 3D CAD models which were used by a Stereo Lithography 3D Printer to produce plastic components. With the exception of a few small parts (i.e. valve springs & spark plugs), the entire engine was made from plastic, this had the added advantage of minimising the weight of the engine. One downside to producing parts from plastic was achieving the correct appearance, this was not a problem for parts that were painted such as the cylinder barrels but it was more of a concern for the metallic parts such as the magneto cover and exhaust manifold. To overcome this, the plastic was metal coated using an electronic deposition technique. The exhaust manifold was even chemically 'blued' to give the appearance of local heat discolouration of a genuine article.

The first assembly of the replica would always be a critical time, not only because it was the first real opportunity to ensure that everything would go together as intended but also because there was very little time to correct any errors. A trial assembly of the radiator, cowls, engine and fuselage was carried out with less than a month to go, some minor adjustments were required but nothing insurmountable. The first full assembly went well but a few small modifications were required and a host of small finishing touches were still required prior to display. It was not possible to conduct a full assembly until less than a week before the display as work on covering and painting the wings was in progress. The remaining finishing touches to the aircraft were still being made on the afternoon before

the display but it was completed in time.

The project was a success. During the Rolls-Royce Families Day, countless people asked where it landed or when the aircraft would fly and the feedback from an ex-Bristol Fighter pilot was that it was “entirely convincing close-up”, which is a fantastic tribute to the hard work of the team.

The ability to easily disassemble, transport and re-assemble the replica was soon put to the test with the replica having to go on public display the following weekend in the centre of Bristol as part of a special service of celebration to mark the centenary of aviation in the city. The long-term future of the aircraft is still to be agreed upon. It is hoped that it will go on permanent public display, possibly in the Bristol Air Collection, but will continue to be used for display events in the future.



The Bristol Fighter on the Filton Airfield following its first full assembly after a ‘roll out’ for the local press with less than a week to go to its first public display.



View of the 3D CAD model used to support the design and manufacture.



The finished article on display at the Rolls-Royce Families Day. Detail included a rotating propeller, moveable radiator slats and control surfaces.



CAD model of the exhaust manifold required to produce the part using Stereo Lithography methods.



The Exhaust manifold just after completion on the Stereo Lithography printer.



The finished exhaust manifold following metal coating



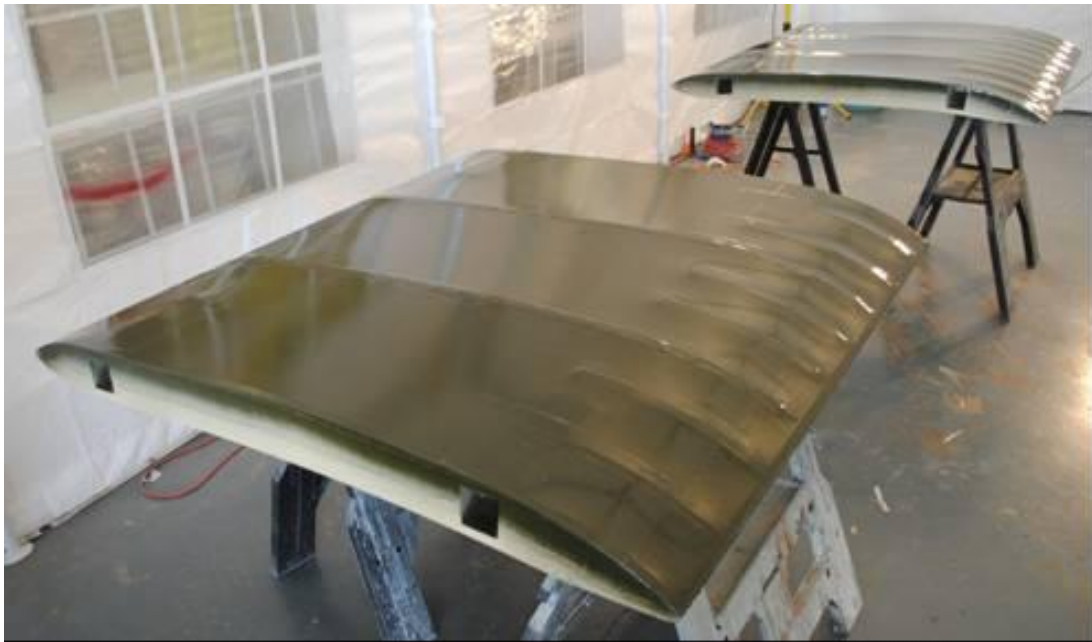
The replica Rolls-Royce Falcon engine – 95% plastic



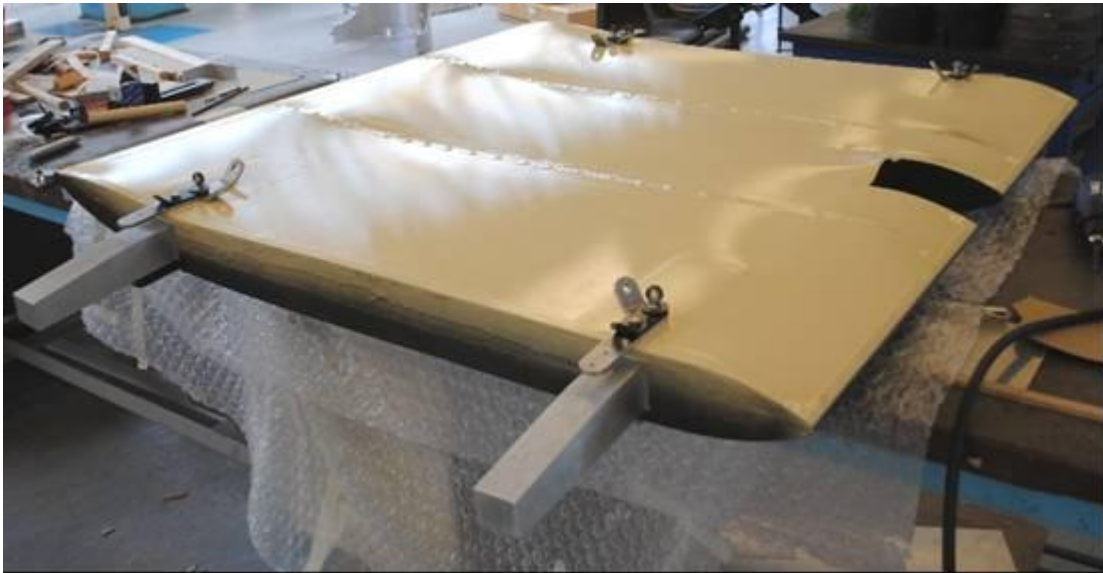
Manufacture of the front end in progress on a mock up of the fuselage.



Centre plane, aluminium box spars with wooden ribs.



Centre plane after covering and painting.



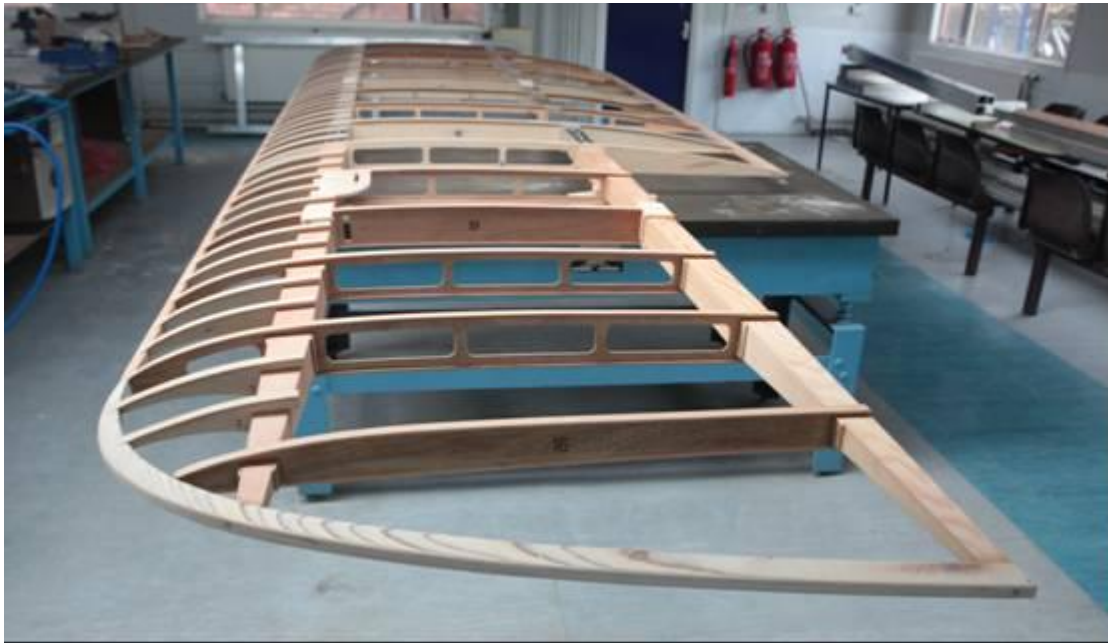
Underside of top centre plane with metal brackets attached and showing the aluminium 'stubs' for attachment of the wings. This was to allow for easy fitting of the wings and reduce the reliance on the wing bracing wires to support the wings.



Main wing rib showing simplified construction being made from 3 pieces compared to approximately 16 pieces on original design.



Construction of wing showing aluminium box spars, ribs and rib front packing pieces.



Lower wing viewed from outer end showing wooden spar. The Spars were made from aluminium box for the inner 2/3^{rds} and wood for the outer 3rd



Lower wing viewed from inner end showing the aluminium main spars.



Underside of lower wing after covering and painting.



Early stages of fuselage manufacture. Each side of fuselage was cut from 3mm ply with the longerons and struts being attached to the ply. The ply provides the strength as the design was not using the original method of metal brackets/fittings and tensioned wires.



The two sides of fuselage joined with the cross members. Also the tail plane front and rear attachment fittings are shown (similar to original design).



View of inner fuselage looking forwards.



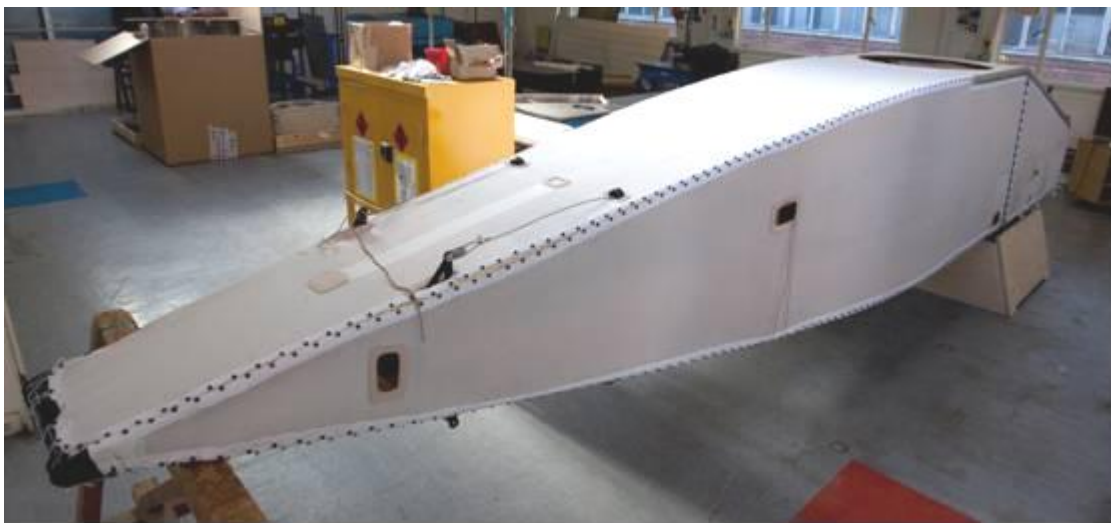
Finished fuselage prior to fabric covering.



View of underside of fuselage front end showing metalwork for mounting of wings and undercarriage and lacing strips for attachment of the fabric covering. Metal brackets were similar to original design.



Front of fuselage after completion of fabric covering.



Finished fuselage after fabric covering.



Front end of fuselage with upper centre plane and bracing fitted.



Trial fit of front end showing engine and radiator mount, dummy fuel tank and radiator.