Design **step-change** propels **Astute-class** submarines

Changes in design, manufacture and project management techniques have not only enabled Rolls-Royce to deliver its first-ever submarine propulsor quickly, but also to use aero engine technology to support an underwater application for the first time

Long before Rolls-Royce was awarded the contract from BAE Systems to extend its supply to a propulsion system for the UK Royal Navy's new Astute class of submarine, the company was already applying a new vision to this challenge by forming a 'concurrent engineering' team. This enables designers and manufacturers to work in parallel so that material purchase and component manufacture can happen ahead of the final 'design freeze'.

The propulsor is a ducted pump jet that works on similar principles to an aero engine, with fixed stator vanes and dynamic rotor blades. It needed to be lighter and more corrosion-resistant than previous designs, so the materials used and the casting quality had to deliver significant improvements.

Above all, the challenge faced by the Rolls-Royce team was that the whole process of design, project management and delivery had to be engineered to meet a programme that was reduced from 42 months to 27. Even the product itself would be installed in a different way. Previously, submarine propulsors have been built as part of the ship. Under the Rolls-Royce contract the Astute propulsor is a fully assembled unit that is delivered to the shipbuilder complete and ready for installation.

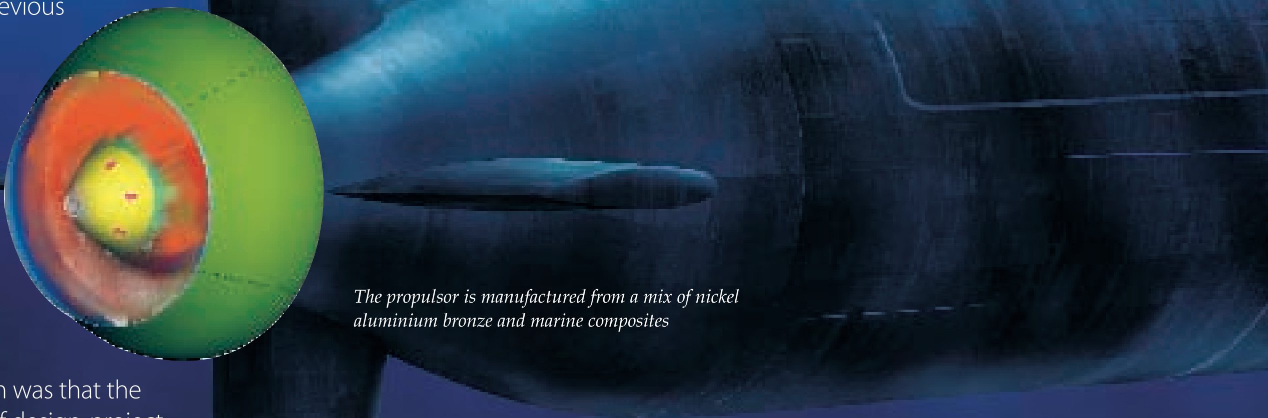
"Some elements of the design criteria, such as the hydrodynamic specification, were pre-determined," says Rolls-Royce materials specialist, John Fowler. "But it was evident to us that the hydrodynamics for mass flow is strikingly similar to that in the aero industry – with water being displaced instead of air.

"The short delivery time and weight limitations were also typical aero industry constraints, so it was logical for us to look at transferring technology and methods from the aero side of the Rolls-Royce business. We had to produce a structural engineering solution that would give considerable performance improvement compared with past propulsion systems," he explains.

In focusing on not just the engineering challenge but on the short timescale available, the propulsor team highlighted the crucial areas forming early teaming agreements with key sub-contractors, adopting simultaneous engineering techniques and taking a fresh look at new design challenges. Excellent teamwork was a vital part of the process.

> **"It was logical to look at transferring technology and methods from the aero side of Rolls-Royce"**

Of the many material options reviewed, the solution was a mix of nickel aluminium bronze (NAB), and a marine composite material to replace the metallic option formerly used for ducts, fillers and fairings. Previous duct designs – requiring metal reinforcement to meet operational loads – failed to meet the high shock



The propulsor is manufactured from a mix of nickel aluminium bronze and marine composites

Astute *class submarines will be powered by the new long-life core, designed by Rolls-Royce to last the life of the platform*

loads for the Astute-class requirement and had contributed to unacceptable acoustic signature levels. These had also suffered from corrosion at sea, leading to significant through-life repair costs.

The new corrosion-resistant duct is a one-piece design, with full-length longitudinal ribs to achieve the required shock-resistance and rigidity. An encapsulated anechoic layer gives the double advantage of exceeding the signature requirements and dispensing with the need for external tiles –and therefore the in-service costs of their replacement. Designed by Rolls-Royce, the composite components are manufactured by one of the key programme partners, Slingsby Aviation.

The use of improved NAB casting technology to produce components brought a number of parallel benefits to the propulsor performance, notably reducing past corrosion problems, improving mechanical performance and reducing weight.

Programme time constraints meant that there was no place – or time – for traditional sequential engineering methods. In its place, Rolls-Royce and its partners used concurrent (or simultaneous) engineering techniques. It is a partly judgemental skill, which involves manufacturers at the beginning of the process to optimise results at the end of it. A sequence of independent assessments and design reviews enables material purchase and component manufacture to take place ahead of the final design freeze.

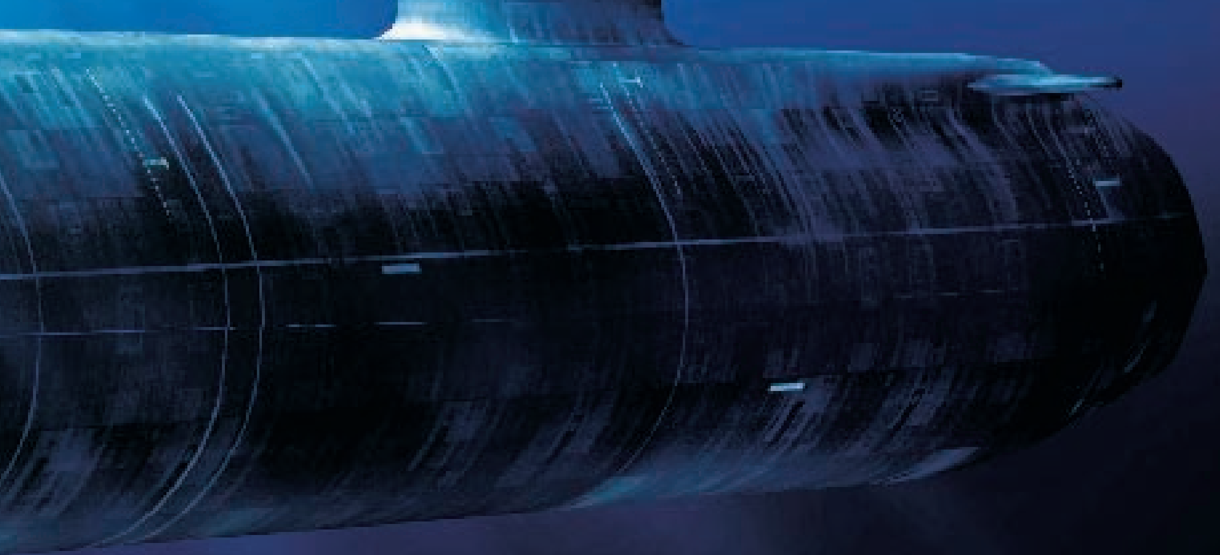
NAB components were cast at the foundry of another key partner in the process, Meighs Limited. An additional time-saving skill introduced by the team was the use of sand-milled rapid prototyping techniques – enabling casting methods to be optimised ahead of serial manufacture.

The underwater signature and engineering performance of the new propulsor duct were investigated in Fraser-Nash Consultancy's laboratories, whilst further research into material performance was carried out in-house at the Rolls-Royce university technology centres in Oxford and Birmingham.

In delivering the new Astute-class propulsor to the customer by addressing stringent new performance criteria, the application of new materials, focused teamwork and new design and engineering methods, the Rolls-Royce propulsor team has demonstrated a step-change in total project management capability.

The Astute propulsor is delivered to the shipbuilder fully assembled and ready for installation

This is also the view of BAE Systems, which has responded to the achievement with the view that the Rolls-Royce team is to be congratulated for its outstanding contribution. BAE's testimony says it all: "The progress you have made has demonstrated a world-class capability and set the benchmark for the future".



Images courtesy of BAE Systems