Astute Class Submarines
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About BAE SYSTEMS
BAE Systems is an international company engaged in the development, delivery and support of advanced defence and aerospace systems in the air, on land, at sea and in space. The company designs, manufactures and supports military aircraft, surface ships, submarines, fighting vehicles, radar, avionics, communications, electronics and guided weapon systems. It is a pioneer in technology with a heritage stretching back hundreds of years. It is at the forefront of innovation, working to develop the next generation of intelligent defence systems.

BAE Systems has major operations across five continents and customers in some 130 countries. The company has more than 90,000 people and generates annual sales of approximately £12 billion through its wholly-owned and joint venture operations.

“....in sea affairs nothing is impossible”
Vice Admiral Lord Nelson
‘Built at Barrow’ – three words with a resonance across the globe. Because anything built at Barrow is part of a unique lineage that stretches back over a century and represents the very best in engineering innovation.

Did you know that Barrow built
- The first 100,000 deadweight ton supertanker
- The first all electric propulsion capital ship for the Royal Navy
- The very first submarine for the Royal Navy
- The four Vanguard Class submarines that carry the UK’s strategic nuclear deterrent
- Every Royal Navy submarine currently in service
- Nearly every first of class capital ship since 1945
The biggest ‘first’ of all - the next generation nuclear powered submarine for the 21st century.
Imagine the most hostile environment on Earth

The crushing black cold of the deepest ocean. For man in the exploration of his home planet, the seas still represent the final frontier and in many ways a journey into the depths is more challenging than a voyage into space.

Of course, operating in such an unforgiving place calls for some remarkable engineering solutions. Especially when the submariners are entrusted with the ultimate safety and security of our territory.

Nuclear submarines (SSN) and Strategic Ballistic Nuclear submarines (SSBN) represent the most powerful warships in the world and are the most complex vehicles devised by man, patrolling the oceans 24 hours a day, 365 days a year and contributing to national and global peace and security. Their stealth and endurance, speed and flexibility gives them unparalleled freedom to operate worldwide.

Designed and built away from the public eye, and then operated in some of the most remote places known to man, submarines are by their very nature a hidden asset when it comes to national defence. But we should take every opportunity we can to celebrate technology and innovation of this calibre.

A new generation

The Astute Class submarine, designed and built by BAE Systems, is a next generation nuclear powered submarine that will be the largest and most able attack submarine that the Royal Navy has operated, with a performance to rival any in the world.

Astute is a potent and invisible threat, a stealthy protector of our territorial waters and in the depths of the open oceans.

Why Astute?

The 1998 Strategic Defence Review reaffirmed the UK’s need for submarines – but with increasingly flexible capabilities.

Astute’s role as an undersea hunter-killer relies on her being stealthier than her underwater environment. Astute will undertake a range of tasks including intelligence gathering, Special Forces and anti-submarine warfare. Designed to operate in isolation or as part of a joint military task force with other naval vessels, aircraft and land forces, Astute’s challenge is to remain undetected, thousands of miles from home and hundreds of metres underwater while still being able to communicate securely and effectively with allied forces via satellite.

Astute has greater weapons capability, improved communications facilities and enhanced capability to operate in the littoral in comparison with the existing Swiftsure and Trafalgar (S&T) Class in service at present.

A powerful threat to enemy ships and submarines, Astute also has formidable firepower against land targets. Armed with Tomahawk cruise missiles she can strike at targets up to 2,000km from the coast with pin-point accuracy.

It’s no wonder that Astute will become the UK’s most capable military asset and weapon of choice in the 21st century – the latest in a long line of boats for that ‘most silent service’.

Did you know?

Astute has a million individual components and 10,000 separate design and engineering requirements.
The £2 billion Astute Prime Contract is for three next generation submarines to replace the Swiftsure Class.

The Prime Contract is the first in the UK for a capital warship. This ‘total systems’ approach has made the incentives for industry much stronger and gives BAE Systems much broader boundaries for innovative design. There have been opportunities to give even greater focus to through-life support in line with the MoD’s Smart Acquisition Policy.

As a company, BAE Systems has considerable experience and expertise in providing ongoing support to its customers.

BAE Systems believes there is potential for a flotilla of these submarines and further contracts may be awarded, provided targets for cost and delivery are achieved.

Customer satisfaction has never been so important

About BAE SYSTEMS:
- An international company with annual sales of £12 billion
- Develops, manufactures and supports advanced military aircraft, ships, submarines and armed vehicles, plus weapon and control systems.
- A proven track record of complex systems integration.
- Benefits from over 130 years of shipbuilding experience.
- A global workforce of over 90,000, meeting the requirements of customers in 130 countries.

Did you know?
Barrow-built HMS Dreadnought, was Britain’s first nuclear powered submarine and the first to surface through the ice of the North Pole.

Delivering and supporting the product
Customer satisfaction

What is promised must be delivered

The UK Ministry of Defence and Royal Navy demands more than a ‘best in class’ – in Astute, they seek to push the boundaries of nuclear submarine technology and capability to new extremes, and only by focusing completely on the customer’s mission requirements can BAE Systems and the Astute team make it the one of the most powerful weapons in the water, with remarkable mission flexibility.

Astute is designed to be fast and stealthy, and in line with customer expectation will play a role in joint and autonomous operations. Fitted with the now proven Sonar 2076 (through the Swiftsure and Trafalgar update programme) Astute can operate and project power without leaving a trace – denying the enemy vital knowledge.

Mission accomplished

Astute may have posed some significant challenges, but our ability to meet customer requirements was demonstrated in the recent contract to refurbish Upholder Class submarines for sale to the Canadian Navy.

This work has been accomplished on time and to budget and the programme has demonstrated the company’s ability to work closely with its customer and with stakeholders such as the UK Ministry of Defence.

What has been learnt from Upholder, together with the drive and commitment to deliver, will be applied to other programmes, and what has been achieved illustrates clearly just what the team is capable of.

Astute may be on a different scale – but this track record of technical excellence coupled with a new sense of customer focus, stands us in good stead.

In more ways than one, Astute is breaking new ground…
Upholder Class Submarine
All the right ingredients

It takes a very special team to produce a first of class submarine – and the Astute team extends far beyond the Barrow shipyard to the wider BAE Systems and out into the chain of suppliers.

You need a careful blend of experience and enthusiasm to push back engineering boundaries and come up with the right solution. That’s why graduates and apprentices are working alongside some of the country’s most experienced specialist engineers in disciplines as diverse as nuclear engineering, hydrodynamics, mechanical engineering and human factors.

It adds up to a winning formula…

But more than that, the level of expertise on the Astute programme adds up to a national asset. We have 770 of the UK’s best engineers, from all disciplines, working on Astute, and through the life of the programme we will welcome more young people into the team.

Programmes such as Astute are vital to maintaining the UK’s skill base and attracting young people to engineering and technical careers. We’re not just building an amazing product – we’re building the skills that contribute directly to the strength of the UK economy.

The depth and breadth of our talent is vital, because modular construction and concurrent engineering techniques have changed the way engineers and technicians have traditionally worked and call for new project management and risk assessment skills.

A different way

Astute has been designed using state-of-the-art three-dimensional computer modelling tools. Modular build techniques are being used on Astute and are bringing benefits in terms of build time and cost.

Construction is carried out in the Devonshire Dock Hall at Barrow, where all major pressure hull and modular elements are brought together for installation and integration.

Work actually started on building Astute’s massive pressure hull long before the system designs were complete. We have demonstrated concurrent engineering at its best in order to manage risk. The design is progressively released to production, so the possibility of major (and expensive) change further down the line is minimised.

In all this, teamwork is vital. Operating integrated design teams means better communication, better understanding and improved focus on the key issues.

Investment in training has been important, but so has the willingness of the team to adapt and adopt new methodologies with enthusiasm and vigour. Everyone has something to contribute; and everyone has something to learn. That’s why the business actively supports Lifelong Learning and Investment in People and builds partnerships with local colleges to help develop our peoples’ skills for the future.

Did you know?
The first three Astute Class submarines will be named Astute, Ambush and Artful. Their operational base port will be Faslane on the River Clyde.

‘I have just completed an apprenticeship at Barrow Barrow and I can’t imagine a bigger or better programme to be involved in than Astute. The engineering challenges are huge, but I’m learning so much from the people around me. Everyone takes real pride in the product…’

Liz Allan, electrical technician.

‘Astute is an amazing vessel – walking through the Devonshire Dock Hall and seeing the scale of the hull close up really takes your breath away…’

Stuart Managh, design engineer.
Astute design and build

You might just add water to the finished product, but the design and build of any surface ship or submarine takes months and years of detailed planning, design, fabrication and testing to prove performance and safety.

The number of engineering disciplines involved in nuclear submarine design is staggering, and each one is interdependent and tightly packaged in a platform operating in an environment every bit as challenging as outer space.

Nuclear power generation, high pressure steam, electrical and fluid power and significant ordnance must all operate in a sealed environment subject to extreme external pressure. Add to all that the need to accommodate 98 officers and men in comfort for months at a time, and the scale of the task becomes clear.

How is it done?

Astute is one of the first nuclear submarines to be designed entirely in a three-dimensional computer-aided environment and breaks away from the principle that submarine performance should be optimised by designing the smallest boat possible with little regard to cost.

The specialist engineers working on the design of Astute are undertaking complex engineering activities such as:

- **Nuclear engineering**: Providing safety and performance improvements to a state of the art Pressurised Water Reactor that is fuelled for life.

- **Systems engineering**: Integrating the thousands of sub-systems that add up to 100km of cabling, 10km of pipework and over 5 million lines of software code – and managing the supply chain, which consists of over 30 main suppliers.

- **Marine and mechanical engineering**: Providing solutions for the propulsive power train, auxiliary systems and life support. Astute has to be quiet, vibration free and robust enough to withstand a nearby underwater explosion.

- **Hydrodynamics and control engineering**: The design of the submarine hull, hydroplanes and control systems to provide control of depth and good manoeuvrability. The submarine is literally ‘flown’ underwater.

- **Human factors**: Ensuring that every system is safely operable and maintainable in all conditions by a relatively small complement compared with previous nuclear powered submarines.

The programme relies heavily on the power of computer aided design and ‘virtual prototyping’ because with a project as complex as Astute there is no time or budget to produce an actual prototype submarine. Instead, ‘virtual’ prototyping is relied upon, harnessing the power of computer test and visualisation, along with continuous design and systems analysis.

Over 1 million components are represented on the three-dimensional CAD model which, together with analysis and integration rigs, represent the completed vessel. The use of three dimensional CAD enables the exchange of critical design data across the supply chain, taking an element of risk out of the programme and allowing change to be implemented efficiently and effectively.

**Astute poses some unique challenges:**

- Its power plant is arguably more complex than a nuclear power station, with many more restrictions placed upon it and with 98 people living and working in close proximity.

- Once deployed, Astute is designed not to require refuelling throughout her full service life – in excess of 25 years.

- Astute will spend her entire life immersed in sea water – a highly corrosive liquid.

- The pressure hull is a 97 metre long cylinder which when submerged must withstand pressure equivalent to 400 family saloon cars weighing down on every square metre of surface area.

- The spatial constraints are enormous. A nuclear submarine is typically three times more densely packed with machinery and equipment than a surface ship.

**Did you know?**

Barrow built major structures for the Lan Tau Fixed Crossing – the world’s longest span suspension bridge carrying road and rail traffic. It is 3.5km long and connects Hong Kong territories with the international airport of Chek Lap Kok. The main span of the bridge is 1.337km.
Striving for high performance...

The submarine business is a key component of BAE Systems’ naval activities. With Barrow designated as a submarine centre of excellence, the business has its eyes set firmly on the future, but it also honours the past and the proud pedigree that comes from100 years of supplying the finest products to the finest naval fighting force.

A century of success

1901: Holland I, the Royal Navy’s first submarine, fitted with a single torpedo tube, is launched at Barrow shipyard.

1914-1918: The Royal Navy enters the Great War with 79 submarines and 31 in-build.

1918-1936: Consolidation for the submarine service as overseas squadrons are established to maintain a British presence across the globe.

1939-1945: The Royal Navy enters World War II with 100 submarines, which fight with distinction, but at tremendous sacrifice in terms of lives lost.

1960: HMS Dreadnought, built at Barrow, starts the line of British nuclear powered submarines that go on to play a pivotal role in the Cold War.

1966: Britain’s first Polaris-armed ballistic nuclear submarine enters service.

1982: Royal Navy submarines, notably HMS Conqueror, play a vital role in the Falklands conflict.

1991: End of the Cold War – the role of the SSN changes.

1991-1999: SSNs of the Royal Navy maintain a vigil for peace. Deployments in the Balkans and the Gulf demonstrate the value of their role in supporting conventional forces.

1999: HMS Vengeance enters service, completing the Vanguard Class of four Trident-armed Strategic Nuclear deterrent submarines that protect the UK.

2001: Astute, the UK’s largest and most powerful attack submarine, is laid down at Barrow.

2003: Keel laying of Ambush – the second Astute Class submarine on order.
...and aiming to be the best
Enduring partnership
Our relationship with the Royal Navy is unique and enduring – we have built nearly every Royal Navy first of class capital ship since 1945.

Astute will provide the Royal Navy with the increased and enhanced flexible capability demanded by the need to support diverse, global missions within ever more network-centric warfare scenarios.

It’s a formidable weapon. Astute can carry a mix of up to 38 Spearfish heavyweight torpedoes and Tomahawk cruise missiles – that’s 50 per cent more than existing Trafalgar class submarines – and Astute’s speed means that she can travel great distances in a single deployment. She can travel between Arctic and tropical waters unseen and without the need to return to base, changing operational roles easily and efficiently.

The Astute Prime Contract also includes the weapons upgrades of boats in the previous Swiftsure and Trafalgar classes of submarines – and Astute’s speed means that she can travel great distances in a single deployment. She can travel between Arctic and tropical waters unseen and without the need to return to base, changing operational roles easily and efficiently.

Surface ships
Barrow’s long relationship with the Royal Navy includes an impressive array of innovations and technical firsts.

For example The Landing Platform Dock ‘Albion’, built at Barrow, was the first warship in the Royal Navy to have fully integrated electric propulsion. The benefits have been enormous, from a 30% reduction in through-life costs to improved low speed performance, improved access and faster offloading.

Two ‘Wave Class’ Auxiliary Oilers have also recently been delivered to the Royal Fleet Auxiliary. Auxiliary Oilers are designed to replenish ships of the Royal Navy fleet and NATO at sea with oil, aviation fuel and stores.

The Wave Class is environmentally friendly, with a double hull to prevent pollution should the outer hull sustain damage. The hull was built as units combined into 12 blocks in the covered Devonshire Dock Hall (DDH) before transit to the superberth and subsequent dynamic launching.

At over 12,500 tonnes unladen, Wave Knight was the largest and heaviest vessel launched at Barrow since the aircraft carrier Invincible 23 years earlier.

Did you know?
Submarines are traditionally referred to as boats – an affectionate reminder of the early submariners who risked their lives in wooden boats covered in greased leather and rowed by oars, to prove the concept of underwater travel.
...we build navies
A nationwide network of sites and suppliers is supporting the Astute contract.

Come and see us

With Barrow designated a submarines centre of excellence, it is supported by the Astute team and the Swiftsure/Trafalgar Class update teams at Farnborough and Weymouth, and the Astute/Swiftsure/Trafalgar Class integration facilities at Ash Vale.

**BAE Systems:**
- Ash Vale
- Barrow
- Derby
- Farnborough
- Filton
- Weymouth

The success of Astute depends upon a number of strategic suppliers to the programme, chosen for their experience and skills. Major suppliers include: Alstom, AMS, Rolls Royce, Strachan & Henshaw and Thales UK.

**Strength in the community**
What would the business be without the strength and loyalty of the local communities around our sites? The people close to our shipyard and to our technical centres play a vital role in the business and in turn we are, in many cases at the heart of local economies.

There is tremendous pride in the products that are produced by the Submarines Business and an understanding of their strategic importance, not just in the local community and in the UK, but in the global arena too.

It’s natural that a coastal community such as Barrow should look to the sea for its economic prosperity. Some Barrow families have seen three or four generations work in the shipyard, and the company takes very seriously its responsibility as an employer with such a long and illustrious history.

Local people are our mainstay in terms of skills and support. Our communities share our history – the highs and the lows – and are a vital component of our future.

**Did you know?**
The Oriana, the largest passenger liner built in England had a crew of 900 and carried 2,184 passengers. She was launched at Barrow in 1959 and is now a floating theme park, museum and banqueting hall in the Chinese port of Dalian.
Fascinating facts

- Barrow shipyard founded in 1871 as the Iron Shipbuilding Company
- James Ramsden, founder and first Managing Director of Barrow Shipyard, was knighted by Queen Victoria
- Barrow’s first submarine Abdul Hamid, built for the Ottoman (Turkish) Navy in 1886
- Vickers family steel business bought Barrow shipyard in 1897 – and owned it until nationalisation 80 years later
- Since its foundation in 1901, the Royal Navy's submarine service has operated 575 submarines – 309 were built at Barrow
- Barrow has built 26 submarines for export and refurbished another four
- Barrow-built submarines have been operated by 17 navies around the globe
- Ten members of the British Royal Family have named and launched ships or submarines at Barrow, starting with Princess Louise in 1903
- Barrow built submarine HMS Thorough, launched in 1943, was the first British submarine to circumnavigate the globe
- HMS Ajax, the ship that found fame at the Battle of the River Plate, was built in Barrow
- Barrow built the famous X-Craft midget submarines that successfully disabled the mighty battleship Tirpitz
- Launched in 1944, the Barrow-built HMS Tiptoe carried a pair of red ballet shoes worn by Hollywood actress Norma Shearer in the film ‘The Red Shoes’. Tiptoe also starred in the film ‘We Dive at Dawn’.
- The passenger liner Orsova, built at Barrow in 1953, was the world’s first mastless cruise liner.
- Between 1986 and 1999 Barrow built the four Vanguard Class submarines that carry the UK’s strategic nuclear deterrent – Trident ballistic missiles.
- Astute Class submarine is 97m long and weighs 7,800 tonnes
- Astute Class submarine can patrol for up to 90 days
- Astute’s sonar suite has the processing power of 200,000 laptop computers
- The Devonshire Dock Hall at Barrow was designed to hold four vessel hulls simultaneously and two in build
- The ship lift at Barrow can raise or lower ships or submarines weighing 23,400 tonnes
- Modular build was introduced at Barrow with HMS Triumph – last of the Trafalgar Class submarines and first to be built entirely undercover in the Devonshire Dock Hall.
- Barrow holds the record for the heaviest load moved on a British road – the complete hull stern block of the Amphibious Assault Ship Bulwark (2,832 tonnes) was moved from the construction hall to the superberth in 2000.
- Britain is one of only five nations in the world capable of building nuclear powered submarines.
- Barrow is the only designated nuclear submarine build yard in the UK.