

ARCHIVED REPORT

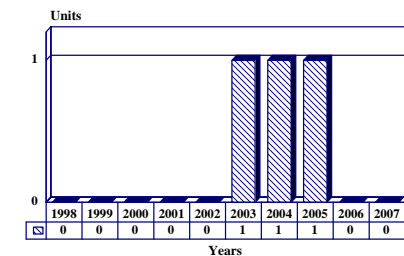
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Trafalgar Class - Archived 1/99

Outlook

- All boats of the original Trafalgar series built
- Will be followed by three Astute class in the future
- Modernization and upgrading of existing systems will continue
- Longer-term, to be succeeded by a new Future Attack Submarine

10 Year Unit Production Forecast
1998 - 2007



Orientation

Description. Nuclear-powered attack submarine (SSN).

Sponsor

Ministry of Defence (Procurement Executive)
 CB/Admin 3
 St Georges Ct
 14 New Oxford St
 London WC1A 1EJ
 UK

Contractor

GEC plc
 GEC Marine
 Barrow-in-Furness
 UK

Licensees. There are no licensees of this class submarine.

Status. In production.

Total Produced. Seven Trafalgar class submarines have been built, and three more Astute class derivatives are planned to be procured.

Application. Location, classification and destruction of hostile submarines, the protection of Royal Navy ballistic missile submarines and the destruction of hostile surface forces.

Price Range. The lead ship of the class is estimated to have cost US\$1.2 billion.

Technical Data

Specifications

<i>Speed, Submerged:</i>	29 knots	
<i>Diving depth:</i>	300 m operating	980 ft
	590 m maximum	1,936 ft
<i>Endurance:</i>	85 days	
<i>Crew:</i>	12 officers, 88 enlisted + 12 spare	

Dimensions	<u>Metric</u>	<u>US</u>
<i>Length:</i>	91.7 m	300.9 ft
<i>Beam:</i>	10.8 m	35.4 ft
<i>Draft:</i>	10.0 m	32.8 ft
<i>Displacement, surfaced:</i>	6,300 tonnes	
<i>Displacement, submerged:</i>	6,800 tonnes	
Armament	<u>Type</u>	<u>Quantity</u>
<i>Torpedo tubes:</i>	533 mm (21 in)	5-6
<i>Torpedoes:</i>	Spearfish	
<i>Mines:</i>	Mark 5 (in place of torpedoes)	(in lieu of torpedoes)
<i>Missiles:</i>	Sub-Harpoon; Tomahawk	(total 38 weapons)
Electronics		
<i>Sonars:</i>		
<i>Active/passive bow:</i>	Type 2020	1
<i>Flank arrays:</i>	Type 2072	1
<i>Intercept sonar:</i>	Type 2019	1
<i>Towed array:</i>	Type 2026	1
<i>Mine avoidance:</i>	Type 197	1
<i>Underwater telephone:</i>	Type 2008	1
<i>Radars:</i>		
<i>Navigation:</i>	I-band	1
<i>Electronic warfare:</i>		
<i>ESM:</i>	Outfit UAP	1
<i>COMINT:</i>	Outfit CXA	1 (some only)
<i>Countermeasures tubes:</i>	SSE Mark 8	2
<i>Torpedo decoys:</i>	Type 2066	1
<i>Periscopes:</i>		
<i>Attack</i>	CH 84	1
<i>Search</i>	CK 34	1
<i>Command & Control:</i>		
<i>Command system</i>	Outfit DCB	1
<i>TDHS:</i>	Outfit DCG	1
<i>SATCOM:</i>	Skynet 4	1
Propulsion		
<i>Nuclear reactor:</i>	Rolls Royce PWR-2	1
<i>Turbines:</i>	GEC	2x15,000 shp
<i>Auxiliary Propulsion:</i>	Paxman 400	
<i>Propeller:</i>	Pump jet propulsor	

Design Features. The Trafalgar Class hull form is a further development of the design used for the earlier Swiftsure class. This is a modification of the basic Albacore form developed jointly by the Royal Navy and US Navy. The form is modified with a cylindrical hull section amidships to ease production and with fuller hull lines aft than the US variants of the Albacore. This reflects the extensive rafting of the machinery aft which carries significant volume and buoyancy penalties. The Trafalgar Class has a further filling out of the aft lines, reflecting the need for additional buoyancy in that area to compensate for the added weight of the propulsor.

Circulating water scoops are installed in the forward edge of the tail control fins. These allow natural water circulation, cutting down on the need to run the main circulation pumps continuously. These pumps are a major source of noise aboard nuclear submarines and by cutting down on their use, the level of radiated noise is greatly reduced. The submarines of the class are covered with anechoic tiles on the hull. These rubber-compound tiles have the ability to absorb and disperse active sonar impulses, reducing the detectability of the submarine. Further reductions in the submarine's noise

profile are achieved by internal sound decoupling layers.

The main propulsion system uses an upgraded PWR 1 pressurized water-cooled nuclear reactor, which drives two geared steam turbines developing 15,000 shp. A Paxman 400 auxiliary diesel provides power for the electric drive which is used in emergencies. The normal propeller has been replaced by a pump jet propulsion system which effectively trades two knots speed for improved silencing over the Swiftsure class. The reactor uses a Core Z, which has a longer life span than the Core B used in previous British nuclear-powered submarines.

Operational Characteristics. The Trafalgar Class has a weapon suite similar to that of the Swiftsure class: five 21-inch torpedo tubes in the lower portion of the bow, with a full load of 20 torpedoes. These tubes can fire either the Spearfish, Mark 24 Tigerfish torpedoes or the Sub-Harpoon missile. The Sub-Harpoon missiles arguably increase the anti-surface capabilities of these submarines but are not popular with the submarine community. The Royal Navy Sub-Harpoon has numerous (highly classified) differences from the US UGM-84 Sub-Harpoon. Mines can be carried in place of torpedoes on a two-for-one basis.

The sonar suite consists of up to 17 sonars including the Type 2019, Type 2020, Type 2072, Type 2026, and Type 197 systems. The Type 2020 is a bow-mounted low-frequency active sonar with excellent passive capabilities. A search and attack sonar, it performs target location and classification and weapon fire control. The Type 2020 replaces the Type 2001, which was carried by the first two submarines of the class. The Type 2072 flank arrays replace the older Type 2007 and form a long-range detection and target location system.

Type 2072 consists of three massive hydrophone arrays spaced down each side of the hull. Most details of Type 2072 are highly classified. Target range can be gained by getting a series of readings and performing Target Motion Analysis. The Type 2026 passive towed array has replaced the Type 2024, which was carried by the first two boats in this class. The Type 2026 uses the Type 2046 dry end processing unit and display system. The Type 2019 is a sonar intercept system using a hydrophone array on the forward part of the hull.

The radar system is a submarine version of the Type 1007 navigation set. This unit gives target bearing and range data when the submarine is at periscope depth. An Outfit UAP (Racal Porpoise) ESM unit is carried. This consists of two separate antenna arrays. One is a radar warning receiver on the periscope mast, the other is a larger and more obtrusive passive intercept system fitted to a separate mast. This is for detecting hostile radar emissions and for providing over-the-horizon-targeting (OTHT) data. Both periscopes, the CK 35 Search and CH 85 Attack, have an infrared sighting capability, split eyepiece for binocular observation, and fittings to mount a 35 mm camera. Target information is shown on the eyepiece or a SAWS (Submarine Above Water Sensor) video display. The CK-35 search periscope is currently being fitted with a GPS receiver system.

The command and control system is the Outfit DCB augmented with an Outfit DCG Tactical Data Handling System (TDHS). The Outfit DCB uses two FM1600E minicomputers. Taking information from all the submarine's sensors, the system can perform target motion analysis on several contacts simultaneously and send guidance instructions to the wire guidance system of the Mark 24 Tigerfish. The system also can give launch instructions to the Sub-Harpoon missiles.

Variants/Upgrades

There are a growing number of changes to the original design. The original Type 1006 radar has been replaced by the Type 1007. The Type 2020 hull-mounted sonar is being upgraded with the Type 2074 display system. Effectively each ship of this class is equipped to a different standard.

Astute Class. This is officially the name of the new class succeeding the Trafalgar class. This boat type was initially referred to as the B2TC (Batch 2 Trafalgar Class).

The Batch 2 Trafalgar Class (B2TC) design will use the detailed drawings of the sixth of the class, *HMS Talent* as the basic start point, but with the PWR-2 pressurized

water reactor plant developed for the Vanguard class SSBNs rather than the PWR 1. The result will be a longer and beamier boat than the existing Trafalgar hull. Internally, compartments will be redesigned to accommodate both the PWR 2 reactor plant and the command and sensor fit – an upgraded BAeSEMA Submarine Command System (SMCS) and the fully integrated Type 2076 sonar suite. The new class will also include nonacoustic sensors with some suggestions that Russian wake-sensing technology has been investigated in this connection. Other major differences almost certainly relate to signature reduction, but the innovation of a non-penetrating mast has apparently been dropped.

The periscope outfit on the new submarine is still not known. The Pilkington Optronics CH-51 search and CK-91 attack periscopes combined with the so-called self protection mast, incorporating electronic support measures (ESM) with data passed directly to the command system via a databus, are likely candidates as they have been developed for the Vanguard class. What are described as sore thumb alterations (essentially minor improvements) to the baseline will also be incorporated.

The UK Royal Navy has placed an order for the Astute class submarines, relegating the Trafalgar class boats to a role where their current equipment will be modernized and upgraded to the latest standards as systems become available.

B2TC. The original, 'working' name for the successor of the Trafalgar class (for Batch 2 Trafalgar Class). See description for Astute Class above.

Command Console Upgrades. BAeSEMA won a contract in early 1997, for the development and supply of command system consoles for the Trafalgar submarines. This system integrates the Submarine Command System (SCS) main tactical display with the remote terminal. The functional integration is supported by the Sonar 2076 displays, which are being developed by Thomson Marconi Sonar (TMS). Hardware will be built and integrated by Ultra Electronics.

FASM. The Future Attack Submarine (FASM) project is a concept development effort by the UK MoD to come up with a new attack submarine that would be in service by about year 2015. This series of combat system study contracts among 29 companies is spread over a period of four years, starting 1997. It is considered the long-term replacement for the Trafalgar/Astute class boats.

The pre-feasibility studies of FASM will be carried out by integrated product teams, bringing together inputs from both industry, DERA (the Defence Evaluation and

Research Agency), and the MoD's Procurement Executive.

HMS Trafalgar had the standard seven blade propeller on completion. However, in May, 1996 she completed a US\$180 million refit at Devenport. This included a full hull survey, structural modifications, upgrading and replacing all on-board systems and recoring the PWR-1 reactor. Usually reliable sources suggest that the structural modifications are the replacement of the conventional propeller by a pumpjet.

HMS Triumph is scheduled to have the Types 778 and 780 upward-looking echo sounders and an underwater TV camera.

HMS Turbulent carries a Type 2044 reeled towed array in a hump aft of the sail; on the other submarines it is a clip on unit. The submarine also has the improved Type 2020 MODEX set. This is part of the trials program for the Type 2054 integrated sonar system being developed for the Vanguard class ballistic missile submarines.

By the mid-late 1990s the original Trafalgar Class boats will be coming in for their mid-life upgrades. This will be a radical upgrade which will install the new Type 2076 integrated sonar suite (comprising the Type 2079 low-frequency bow-mounted passive/active sonar, the high-frequency Type 2077 under-ice navigation sonar, the Type 2081 oceanographic environmental sonar suite, the Type 2082 active sonar intercept suite and the Type 2044 towed array). This comprehensive system will be combined with the SMCS command management system and the new SAWS (Submarine Acoustic Warfare System) defensive countermeasures suite. The electronic warfare equipment will also be enhanced. The Royal Navy claim that this integrated system, which will also equip the Batch 2 Trafalgar Class submarines, will provide capabilities equivalent to those offered by the US Navy Seawolf class at substantially lower cost.

Program Review

Background. This submarine class is part of the Royal Navy's buildup of its nuclear-powered attack submarine forces. They are an outgrowth of the preceding Swiftsure class, but with a quieter propulsion system (achieved at some cost in speed), improved endurance, upgraded sensors, and anechoic tile coating.

Submarine development in the Royal Navy has followed an evolutionary pattern, with each class being an improvement on, rather than a radical change from, the previous class. The Royal Navy began design studies for a successor to the Swiftsure class in 1975, while that class was still being built. The new

submarines were to take advantage of new sonar and propulsion systems under development (Type 2020, 2024/2026 and pump jet propulsion). The reports of a new class of Soviet submarine, Project 705K (NATO codename Alfa), did much to hasten the plans.

The first submarine, *HMS Trafalgar*, was ordered in April 1977 from Vickers Shipbuilding and Engineering Limited (VSEL). Construction began in April 1979. By the time it was launched in July 1981, three more submarines had been ordered, and work was progressing on two. *HMS Trafalgar* was commissioned in May 1983, with *HMS Turbulent* following in May

1984. The first submarine with the new sonar systems, *HMS Tireless*, was commissioned in October 1985. Two months later the Royal Navy ordered the seventh and last Trafalgar Class submarine, *HMS Triumph*.

In mid-1987 Canada's Department of National Defense (DND) issued a White Paper calling for the procurement or construction of 10 to 12 nuclear-powered fast attack submarines. The Royal Navy and VSEL offered the Trafalgar design. France countered by offering the Rubis class as an alternative. The Royal Navy sent the submarine *HMS Torbay* to Halifax, Nova Scotia, to let Canadian naval officers familiarize themselves with it. Most Canadian naval officers favored the Trafalgar design, but some preferred the French submarine. Both of Canada's opposition political parties came out against the nuclear submarine program, and even the governing Conservative party was not unanimous in its support.

Some US Navy officials also objected to this program, mistakenly suggesting that the terms of the 1959 Anglo-American agreement which provided the Royal Navy with an S5W reactor for *HMS Dreadnought* required the United Kingdom to seek United States' permission to transfer the technology to a third nation. Britain had already made clear that it did not require and would not seek US approval for such a transfer. The Canadian DND decided in May 1989 not to proceed with the nuclear-powered submarine program due to the high costs.

During 1990, the Royal Navy initiated a modernization of the Trafalgar Class. This included the retrofit of the Type 1007 radar, the Type 2046 processing system for the Type 2026 towed array in some cases and upgrading the Type 2020 sonar with the Type 2074 processing and display package. This is an interim stage aimed at bringing the seven boats to a common standard before they enter their first full mid-life in the middle/late 1990s.

In April 1991, models of a putative Anglo-French submarine were shown at the Bourget Navale exhibition. These were purely theoretical exhibition-only displays by a private company and do not have any official recognition or procurement significance; at the present time there are no plans for the construction of such submarines. Reports in 1993 that such plans had been abandoned due to the inability of the UK to supply details of its reactor technology without first gaining US approval were without foundation. We must repeat and emphasize, the UK government does NOT require US approval for any transactions involving nuclear powerplants in submarines and has absolutely no intention of seeking such approval should the occasion arrive.

In February 1987 the Ministry of Defence issued two design contracts for SSN-20. This was the designation for the Royal Navy's next class of nuclear-powered fast attack submarines. One contract went to VSEL for design studies and the other to Rolls-Royce to develop an advanced nuclear reactor, designated PWR 2. In 1992 the Royal Navy announced that it would not build the SSN-20 class submarine. In its place the Royal Navy initiated the design process for a second batch of Trafalgar Class boats. During September 1993, Vickers Shipbuilding and Engineering Ltd (VSEL) and other prospective contractors outlined the basic specification of the new Batch 2 Trafalgar Class (B2TC) nuclear attack submarines (see Variants/Upgrades section).

Ministry of Defence (MoD) sources have confirmed that three B2TCs are in the defense costings. There are suggestions that this could increase to six, although it is acknowledged that numbers could also fall. Prior to the RN&BAEE exhibition it had been suggested that an Invitation to Tender (ITT) for B2TC could be delayed to 1996 or even 1998. It was anticipated that consortia led by VSEL and GEC-Marconi Naval Systems would bid for the B2TC prime contractorship. Industry expectations of a draft ITT emerging before the end of 1993, with a definitive ITT to follow early in 1994, were only slightly optimistic.

In fact, a definitive invitation to tender (ITT) for the development of the Batch 2 Trafalgar Class submarine design was issued as part of the Front Line First defense review in mid-1994. This invitation envisaged the construction of the first three B2TC class submarines, with options included for two additional hulls. At that time, it was projected that the three-ship order would be placed in June or July 1996 for delivery starting from 2004. The actual ISD date for the B2TC program is classified, however UK government sources do reveal that the project is running 28 months late as of July, 1996.

A further major development in the Trafalgar Class has been the decision to acquire Tomahawk land attack missiles from the US. A total of 65 missiles are understood to form the first batch with subsequent procurement increasing this to 180.

GEC Marine, which had been formed by the purchase of VSEL and the merger of the appropriate elements of the existing GEC organization, was awarded the contract to be prime contractor for the B2TC program in January 1996. The construction contract was to have been awarded by the end of that year but, as of November 1996, there was no indication that the award was imminent.

Funding

The program is funded by the Ministry of Defence at a 1985 estimated cost of US\$2.0 billion. The annual running cost of a Trafalgar Class submarine is US\$15 million.

Recent Contracts

<u>Contractor</u>	<u>Award (US\$ millions)</u>	<u>Date/Description</u>
Marconi Defence Sys Ltd	1.55	<i>July 1991</i> - Manufacture a new towed submarine communication antenna.
VSEL BAeSEMA	9.0 N/A	<i>1992</i> - Design studies for Batch 2 Trafalgar Class <i>March 1993</i> - UK MoD contract for a design authority technical assistance contract related to the support of the nuclear-powered submarine fleet.
Ferranti Int	15.0	<i>Feb 1994</i> - UK MoD contract for the development of a tactical weapons system highway for the Trafalgar Class submarines. This will integrate the Type 2076 sonar suite with the SMCS command system and the weapons handling and discharge equipment.
Racal Thorn	3.8	<i>Jun 1995</i> - Installation of GPS receiving system into ESM receiving array Outfit AZE(1) to bring the system to Outfit AZE(2) standard.

Timetable

	1976	Ministry of Defense announced new submarine
Sep	1977	<i>HMS Trafalgar</i> ordered
Apr	1979	<i>HMS Trafalgar's</i> keel laid
Jul	1981	<i>HMS Trafalgar</i> launched
May	1983	<i>HMS Trafalgar</i> commissioned
Dec	1985	<i>HMS Triumph</i> (last submarine of the class) ordered
	1987	Canada expressed interest in Trafalgar Class submarine
Jun	1987	US Administration approved nuclear technology export to Canada
	1992	<i>HMS Triumph</i> commissioned
	1994	ITT for B2TC issued
Jan	1996	Prime contractor for B2TC selected
	1997	Construction contract award

Worldwide Distribution

Seven submarines of this class are in service with the Royal Navy.

Forecast Rationale

The seven Trafalgar Class submarines are the backbone of the Royal Navy nuclear-powered submarine force. Their immediate predecessors, the Swiftsure class, are rapidly developing the same serious machinery problems that forced the early retirement of the

Churchill and Valiant class submarines – in fact the lead ship, *HMS Swiftsure*, has already been retired from service for this reason. Correcting the problems (cracking in the primary reactor cooling circuit piping and reported difficulties with containment plating) costs

an estimated US\$400 million and can take up to four years. Any long-term commitment to this level of expenditure cannot be justified.

Following a major internal debate within the Royal Navy Department of Operations, the decision was taken to substantially accelerate the B2TC program, with the ITT to be issued about three years earlier than planned. The number of hulls in the upcoming Astute class has been announced as three, with the probable goal of replacing the remaining Swiftsure boats.

No export of the Trafalgar is projected at present. It is not British defense policy to export nuclear-powered submarines except under very special circumstances. Canada was such a case; Australia would be another if the occasion ever arose, although it is unlikely, and France could be a third such country. Still, all three countries are highly theoretical as buyers of British submarines in today's world.

Construction of the initial batch of Trafalgar class submarines is now complete. Emphasis in the 1993-

1996 budgets was on amphibious warfare ships. However, delays to the CNGF (Project Horizon) air defense frigates has pushed the major funding hump for these ships back at least five years. This has freed up major capital resources for submarine construction. As much as any other consideration, this factor probably explains the speed with which the B2TC (Astute) program has progressed. It is for this reason more likely that construction will include starting a new submarine every other year, rather than at the previously foreseen rate of one boat a year.

The forecast shows the three Astute class submarines ordered in 1997, with deliveries estimated in 2003-2005. No more hulls of this class will be bought, since the class will be replaced by the upcoming Future Attack Submarine (FASM) concept.

A new report will be available on the Astute class in the near future, while the development of the FASM will be also closely monitored. A separate report on that program, too, will emerge at a later date.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR PRODUCTION

Designation	System	thru 97	High Confidence Level				Good Confidence Level				Speculative		Total 98-07	
			98	99	00	01	02	03	04	05	06	07		
TRAFALGAR CLASS	NUCLEAR ATTACK SUBMARINE (UKRN)	7	0	0	0	0	0	0	1	1	1	0	0	3