Draft Technical Chapter for Trident Book

The aim of this chapter is to describe the existing British Trident system in layman's terms, covering the technical facts so far as they are publicly known, the dependence of the whole system on American support, and the options for keeping a British deterrent system going into the indefinite future.

The existing British Trident system.

The Trident system consist of three principal components:

- Four Ballistic missile submarines: Vanguard, Victorious, Vigilant and Vengeance, built in Britain,
- 58 Trident II (D5) missiles bought from the United States,
- 'Fewer than 200' operationally available nuclear warheads made in Britain.

The submarines.

The four submarines were built by Vickers Shipbuilding and Engineering Limited (now BAE Systems Marine) at Barrow in Furness and came into service between 1994 and 1999. They are based at HM Naval Base Clyde at Faslane and are refitted at Devonport Royal Dockyard. This is owned and operated by a firm DML in which the American firm Halliburton KBR owns a controlling interest of 51% [i]. The boats are very large: 150 metres long and 12.8 metres wide, with a draught of 12 metres and displacement of 16,000 tonnes. They are equipped with 16 missile tubes for Trident D5 missiles. For self defence they have four torpedo tubes for Spearfish homing torpedoes[ii], bow, flank and 'towed array' sonars, and collision avoidance radars. They have communication links to the Commander-in-Chief Fleet at Northwood, the Defence Secretary and the Prime Minister, so as to keep the use of the nuclear weapons under firm political control. The Trident boat is propelled by a Rolls Royce PWR2 (Pressurised Water Reactor) driving two GEC steam turbines, which give a submerged speed of 25 knots. It can travel great distances[iii] and for many years without refuelling. It carries a crew of 17 officers and 134 ratings, all male. The accommodation is arranged on four decks and the messes serve not only as dining rooms but lecture halls, lounges, games areas and venues for church services. Members can receive short messages from home once a week but since 'radio silence' has to be absolute these cannot be returned. Only one submarine is on deterrent patrol at any time, the average length of a patrol being between 70 and 80 days at sea. This submarine is normally at several days notice to fire and its missiles are 'de-targeted'[iv]. It can therefore carry out a variety of secondary tasks without compromising its security, including hydrographic data collection, equipment trials and exercises with other vessels.

The Missiles.

Vanguard Class submarines are equipped to carry 16 Trident missiles. Britain has bought 58 Trident II (D5) missiles. These are either deployed on board the British submarines, or held ashore at Royal Naval Armament Depot Coulport (Loch Long)

on a temporary basis, or in America at the Strategic Weapons Facility Atlantic (Kings Bay, Georgia) as part of a shared pool of US/UK missiles. They are built by Lockheed Martin Space Systems at Sunnyvale, California. The missile is a three-stage, solid propellant, inertially guided missile, made of graphite epoxy. It is 44.5 ft. long, 83 in. in diameter and weighs 58 tons. The range from submarine to target is given as 'over 4000 nautical miles' and the time of flight, according to range, of up to 30 minutes. The launch from the submarine occurs under water. The missile is ejected from its tube using pressure created by a solid-fuel rocket motor attached to the bottom of the missile tube which heats a pool of water, creating steam. Ideally, the missile is sheathed in bubbles for its entire time submerged, so water never touches it. After the missile has left the water the first stage motor ignites, an aerospike[v] extends, and the boost stage begins. Within about two minutes, after the third stage motor fires, the missile is travelling faster than 6 km/s.[vi] The missile carries a number of multiple independently targeted re-entry vehicles (MIRVs), each with a nuclear warhead. The D5 missile is designed to carry up to 12 MIRVs[vii].The missile's inertial system calculates flight trajectory and provides guidance. After the third rocket motor has separated, the warhead carrier (or Post Boost Vehicle – PBV) takes a sighting on two stars to confirm its position. Using gas generators and nozzles the PBV aligns itself so as to dispatch the re-entry vehicles (RVs) in turn, each with its own point of aim.[viii] Decoys and penetration aids, nested among the RVs, are also deployed at this stage.[ix] All this takes place during the first one-third of the missile's trajectory. The RVs are not powered and the remaining two-thirds of their flight is ballistic (i.e. free-fall). They are cone shaped and fly at speeds between Mach 15 and 20 outside the atmosphere, slowing to Mach 10 during re-entry. Re-entry generates great heat which is absorbed by burning off the outer surface of the casing ('ablation'). The RVs are spun off their carrier by means of a small explosive charge. The spin maintains the correct attitude for re-entry and ensures that the casing cooks evenly during ablation. The accuracy of strike on target is given by the circle of equal probability (CEP), which is the radius of the circle within which half the strikes will impact. For Trident D5 the CEP is given various values by different writers, lying between 100 and 500m. The Royal Navy describes this as an 'accuracy that can be measured in metres' - which is undeniable.

Target planning and fire control.

Once a Trident submarine has launched a missile its location has been compromised and it is in danger of attack. It follows that the classical mode of operation is a ripple launch in which all the missiles are discharged within about ten minutes. Since this could, in theory, involve sixteen missiles each carrying twelve RVs (i.e. 192 different points of aim) the procedure is highly complex. Target planning takes place at the Nuclear Operations and Targeting Centre (NOTC) in London. Details for pre-arranged targets are supplied to the submarine on magnetic tape. Data can also be transmitted to the submarine by radio. The fire control system on the submarine receives the target data, updating the target database as necessary and assigns targets to missiles. It receives data on the exact position and speed of the submarine from the ships inertial navigation system and navigational sonar.[x] It

receives information on the strength and vertical deflection of gravity, both at the launch point and throughout the missile's trajectory, since this affects both the flight path of the missiles and the inertial navigation systems on the boat and the missiles.[xi] It also needs information on the air density and wind speeds to be experienced by the RV during the final stages of its trajectory. It then allocates targets to RVs within the footprint of each missile, prepares the guidance system for each missile before launch, calculates the steering data for the missile and all its subordinate RVs and coordinates the launch sequence. At the last minute it sends an 'Intent Word' message to each missile. While in flight this message is communicated to each RV where it plays a crucial part in enabling the arming of the warhead. All this is performed on four computers networked together. The software is reported to contain more than one million lines of code. It has not been disclosed how long the process takes. A reasonable guess would be a few minutes for a single missile and a matter of a few hours for the whole boatload.

Warheads.

The UK Trident RV[xii] is manufactured at the Atomic Weapons Establishment (AWE) at Aldermaston. AWE Management Limited is a joint venture company in which the American company Lockheed Martin has a one-third share. The Warhead has been described as a 'Dutch Copy' of the American W76 warhead. This was manufactured in large numbers between 1978 and 1987 and deployed on D5 missiles. It has a yield of about 100 kilotons[xiii] and is the mainstay of the US nuclear deterrent system. A report in the Public Record Office says that the American design was 'anglicised' at Aldermaston.[xiv] The description that follows is based on the American W76 warhead except where stated. The RV consists of the Heatshield, the Arming, Fusing and Firing system (AF&F), the Nuclear Explosives Package (NEP) and two subsidiary components: the Neutron Generator and the Gas Transfer system whose function will be described shortly.

The Heatshield, as already mentioned, is conical[xv] and its function is to protect the warhead during re-entry by means of ablation. It is made of rayon-based carbon phenolics. Starting in 1977 Lockheed Martin built some 5000 kits, including those for the British. The kits include the connectors to the Post Boost Vehicle and the release assembly which finally spins off the RV.

The Arming, Fusing and Firing System prepares the warhead for detonation in about a dozen separate steps controlled by a programming module. Its components include a battery, a timer and a radar that can detonate the warhead either as a high- or low-airburst. There is also a contact fuse. The system includes two safety links that can prevent detonation: an accelerometer to detect the launch of the missile and initiate the arming sequence; a decelerometer to detect a prescribed number of 'Gs' during re-entry and enable the warhead to be detonated. The Firing system supplies high-voltage power to initiate detonation and includes a ferroelectric firing set using a small amount of explosive to generate a pulse of high current, and a vacuum-tube switch that can very rapidly switch it on.

The Nuclear Explosives Package is the heart of the weapon. The system is a thermo-nuclear one which means it contains two principal nuclear assemblies. The **Primary** is a spherical assembly that produces a fission yield through implosion. It

consists of a series of concentric spherical shells. The outermost is made of high explosive and is detonated at a number of points simultaneously with the utmost precision, to ensure that the resultant inward shock wave is as spherical as possible. The innermost is a hollow sphere of about 4kgs of plutonium - known by Americans as the 'pit'[xvi] - which under the intense pressure of the explosion contracts to form a supercritical mass and detonates by nuclear fission (i.e. as an atom bomb). Between these two layers is a shell of beryllium[xvii]. Its function is to contain the critical mass in the centre for as long as possible and to reflect back neutrons which have escaped from the exploding pit, thus lengthening and intensifying the explosive phase. Two other measures are taken to enhance this process. Just before the explosion gaseous tritium is injected into the centre of the pit, boosting the yield by a fusion reaction. This is the function of the Gas Transfer system mentioned above. To start the detonation an ample supply of free neutrons is needed. The Neutron Generator, a miniature particle accelerator about the size of a soda can, fires a few instants after the high explosive to produce a flux of neutrons at the supercritical moment. All these events have to be accurately synchronized within a matter of nano-seconds[xviii].

The **Secondary** is the fusion component of the weapon, increasing its yield by a factor of about ten. Fusion takes place when light elements are exposed to extremely high temperatures, of the order of several 100 million degrees centigrade. This temperature is need first to strip away the electrons from the atomic nuclei and then to overcome the natural charge repulsion of the nuclei themselves. It is almost impossible to achieve this for normal hydrogen but takes place more easily between two isotopes of hydrogen, deuterium and tritium[xix]. If forced together these nuclei fuse and then break apart to form a helium nucleus, a free neutron and a huge excess of energy. It happens that when Lithium Deuteride (a dry substance) is exposed to the neutron flux produced by a fission explosion it breaks up to produce free tritium. In the extreme heat of the fission explosion this tritium can fuse with the remaining deuterium in the lithium deuteride to produce the effects just described, so there is no need to include tritium separately. The fusion fuel in the Secondary is therefore normally a form of Lithium Deuteride. It is usually depicted as a column of fusion fuel. This is wrapped in a cylinder of unenriched uranium or lead[xx] to help compress the fusion fuel, and inside it lies a hollow column of fissile fuel (Plutonium or Uranium-235). Due to its shape this is not originally a critical mass, but becomes so when the secondary detonates, thus adding to the power of the explosion. [xxi]

The **Radiation Case** is the metal cladding of the Nuclear Explosives Package. The primary and the secondary are immediately adjacent and the crucial function of the Case is to channel radiation energy from the one to the other before the whole assembly is blown apart by blast. Since the duration of the entire process is measured in tens of nanoseconds the importance of this function is self-evident.[xxii]

<u>The missile-warhead mix.</u>

The combination of missiles and warheads adopted for British Trident has never been given officially, except to say that the single submarine on deterrent patrol carries 48 operationally available nuclear warheads onboard[xxiii]. Given the known

characteristics of the system, and assuming the missiles are uniformly loaded, this total could theoretically be made up in any one of five ways: 16 missiles each with 3 warheads, 12 missiles each with 4 warheads, 8 missiles each with 6 warheads, 6 missiles each with 8 warheads or 4 missiles each with 12 warheads [xxiv]. Most commentators give the standard load for British Trident missiles as 4 warheads (and by implication twelve missiles on the boat). This seems reasonable, lying well within the limiting numbers both for missiles and warheads and leaving plenty of room and payload on the post-boost vehicle for dummy warheads and penetration aids. However it is unconfirmed. And a complication arose even before British Trident came into service. In the autumn of 1993 the then Defence Secretary Malcolm Rifkind announced a new role for the system resulting from the imminent renunciation of all British owned or operated tactical or 'theatre' nuclear weapons. He said that because against certain enemies the threat of an all-out nuclear assault might not be credible it was important for Britain to be able to 'undertake a more limited nuclear strike' and so to deliver 'an unmistakable message of our willingness to defend our vital interests to the utmost'[xxv]. This is generally described as a 'sub-strategic' role. It was immediately assumed that this limited strike would be carried out by a missile carrying a single warhead, and there have been official statements seeming to corroborate this point[xxvi]. Because the discharge of a single missile would compromise the location of the boat and render it vulnerable it has been suggested that a 'second' vessel might be used, rather than the submarine on patrol [xxvii]. And there have also been indications that this role could be more effectively carried out using a lower yield warhead[xxviii]. There is no difficulty in principle with this suggestion. A yield of about ten kilotons could be obtained by replacing the secondary with an inert dummy of the same weight and inertial characteristics. A yield of about one kiloton could be achieved by additionally switching off the tritium gas injection system. However it has been said that no additional costs have been incurred on account of the sub-strategic role[xxix], which implies that no changes of any substance have been made to the hardware. It has also been explained that a missile with a single warhead could be used in either a strategic or sub-strategic attack[xxx]. This raises the possibility of other missile/warhead loadings for the submarine on patrol. Obvious combinations include 11 missiles with 4 warheads plus four missiles with single warheads. Or the total of 48 onboard warheads could be reduced.[xxxi] These points are all moot. They are not, perhaps, of great importance. But the secrecy is clearly deliberate and it may well be that the Ministry of Defence is content if the flexibility, and hence credibility of sub-strategic Trident is overestimated by the world at large

Dependence on the United States

At a meeting in Nassau, Bahamas in December 1962 between the US President Kennedy and British Prime Minister Macmillan it was agreed that the US would make available, on a continuing basis, ballistic missiles[xxxii] (without warheads) for British submarines and certain support facilities for them. The Prime Minister undertook that these British forces would be used for the purposes of international defence of the western alliance in all circumstances 'except where Her Majesty's

Government may decide that supreme national interests are at stake.'[xxxiii] Since then the United Kingdom has committed all its nuclear forces, both strategic and sub-strategic to NATO.[xxxiv]

Four years previously, under the Mutual Defence Agreement of 1958, the US agreed to sell to Britain a complete submarine nuclear propulsion plant, the necessary information to design, manufacture and operate such a plant and sufficient enriched uranium fuel for ten years of operation. In an amendment the following year the US agreed to supply Britain with non-nuclear parts of atomic weapons systems, together with 'special nuclear material'[xxxv] required for research, development or manufacture of atomic weapons where the transfer of such material was necessary to improve the United Kingdom's capability in these areas. The UK would transfer to the US similar materials for military purposes.[xxxvi] This arrangement has been recently extended, by agreement between the President and the Prime Minister, for a further ten years till December 2014.[xxxvii] These agreements have underpinned the close and continuing link between the two countries in constructing, operating and maintaining the British strategic nuclear submarine force over the past forty years.

<u>The submarine, its communications and navigation systems</u>

The Trident submarines have been built in Britain to British designs though based in part, no doubt, on the design of the American Trident Submarines, the Ohio Class.[xxxviii] The same applies to the nuclear reactor which will owe much to American assistance under the agreements described above. Rolls Royce and associates have developed a new fuel core for British submarines which has been on test at HMS Vulcan, Dounreay for the past five years and is being installed on Trident submarines as they come up for refit. However these cores run on uranium enriched to around 98%. Britain does not enrich uranium to this degree and the final stages of enrichment are carried out at Portsmouth Ohio. According to a 1997 press release the UK had by then received some 7.5 tonnes of enriched uranium over the years, in exchange for some 5.4 tonnes of plutonium[xxxix]. Recently stocks are reported to have been low.

Secure radio communications are essential for these submarines. They are also problematic, because raising an antenna above the water can lead to early detection. A submarine can receive signals, without having to do this, in the radio bands known as Low Frequency (LF) or Very Low Frequency (VLF). A new VLF transmitter at Skelton, near Penrith, operated by VT Merlin Communications, is the primary means of communicating with British Trident submarines[xl]. The same firm is supplying new VLF receivers for the boats. There is also a NATO VLF network, with transmitters at Anthorn, Cumbria and in Norway, Germany and Italy. America also has a VLF/LF network with transmitters in the US and in Puerto Rico, Iceland and Italy, primarily to communicate with US Navy Trident submarines in the Atlantic. This network now provides channels compatible with NATO and hence with the UK. A NATO-wide code for transmitting data is now in use. There is also a bi-lateral system allowing the US Trident Commander at King's Bay, Georgia to communicate directly with British Trident Submarines.

To communicate with satellites the submarines have to raise their antennae above water for a few minutes. Even then there are problems of low bandwidth. British submarines

have access to British, NATO and US satellite systems, operating in the Ultra High Frequency (UHF) and Super High Frequency (SHF) Bands. In nuclear war these satellites might have been disabled by high altitude nuclear bursts[xli]. The US is accordingly introducing a new Extremely High Frequency (EHF) system for strategic nuclear forces. British EHF communications will rely on the use of an American satellite. New shore-based terminals will then provide 'robust, high data-rate satellite communications to British submarines', [xlii] but only by courtesy of the US.

Navigation is also a major concern since knowing the submarine's exact position is critical to accurate targeting. Four systems are used: (i) The Global Positioning Satellite (GPS) system was specifically designed to provide navigational fixes for submarines. It is owned and operated by the US and the British have to use the same system, at least until such time as the European Galileo system goes live in a few years time.[xliii] GPS is extremely accurate, but the signals cannot be received under water. Raising the aerial risks compromising the submarine and the satellites may not survive in a nuclear war. (ii) Between GPS fixes the boat's position is tracked by an inertial system - using gyroscopes to record direction and accelerometers to record distances moved. The British use the same system as the Americans but could, at a pinch, devise their own. (iii) Navigational Sonar Systems measure the speed of the submarine over the sea-bed and the depth of water under the boat. The latter is compared with a map of the sea-bed to help fix the submarine's position. It is not known what type of navigational sonar is used on British Trident submarines. (iv) Mapping. This is crucial to Trident operations for two reasons: first to help in navigation as just mentioned and secondly because of the importance of gravitational data in computing the flight path of the missiles as explained earlier. The US Navy has surveyed small areas in detail to support Trident operations, under its Ocean Survey Programme.[xliv] The submarines on deterrent patrol operate only in these areas, using map data provided in digital form. Their location and the related data are therefore highly classified. The British hydrographic ship HMS Scott is equipped to provide data in a format compatible with the American system. No doubt British submarines patrol in areas surveyed by this ship. It is not known whether patrol area data is exchanged with the Americans. If not this must severely limit the choice of areas for the British.

<u>The missiles and their targeting.</u>

The D5 missiles used on British Trident are American. The hardware and much of the software associated with their targeting and firing are also of American provenance. The 58 missiles 'bought' by the UK are not British exclusive property but form part of a 'shared pool of US/UK missiles' [xlv] based on the Strategic Weapons Facility Atlantic at Kings Bay, Georgia.[xlvi] The weapons are collected from there by British submarines and returned there for refurbishment as necessary. The during a month-long work-up period under American supervision missiles are test fired from British submarines at the US Eastern Test Range, Cape Canaveral,[xlvii], and the missile flight data are analysed to assess reliability and accuracy at John Hopkins University Applied Physics Laboratory at Laurel, Maryland. [xlviii]

Hardware for the Fire Control System (FCS) on Trident submarines is produced by the American firm General Dynamics Defence Systems. It has recently been upgraded to allow for more rapid re-targeting of missiles and to incorporate more commercially

replaceable components. The new FCS entered service on British Trident submarines during the winter 2002/3.[xlix] It appears to be very similar to that being introduced on the American boats. Software for this system is developed by a division of the Naval Surface Warfare Centre at Dahlgren, Virginia. This software has also been upgraded recently. Again there is good reason to suppose that the British version is almost identical to the American. For example a contract was let in 2002 to the Firm CACI [l] at Arlington, Virginia, for software testing and support for the Trident FCS, of which the UK will pay a 10% share,[li] and in April 2005 the US Navy won a contract for 'UK Intent Word Displays' for the British system. [lii] The software for the computers in the British Targeting Centre, NOTC, is also based on American models.
Given that the Royal Navy uses American software for target planning, data handling and fire control, it has been suggested that these programmes may have been doctored to require approval by US Strategic Command (STRATCOM) before they will work. It is even possible that, hidden among the million or so lines of code in the Fire Control System, a few lines might have been inserted to restrict target locations within particular bounds: for example to rule out an attack on the United States - or on Russia unless authorized by the US. There is no evidence that anything like this has ever been done. But it is possible; and if it were then it is most unlikely that the British would ever spot it.

Warheads

As the AWE Annual Report for 2004 explains, co-operation with the US on nuclear weapon matters, under the 1958 Mutual Defence Agreement, 'covers every aspect of weapon design, development and maintenance'. [liii] So no one doubts the description of the British Trident Warhead, quoted earlier, as an American W76 warhead 'anglicised' at Aldermaston. It is generally assumed that all the items of the Re-entry Vehicle outside the Nuclear Explosives Package are of American supply. The Heatshield kits, as already explained, were made by Lockheed Martin. The arming, fusing and firing (AF&F) systems for the British warhead were designed by Sandia National Laboratories, and are almost certainly bought from the United States *in toto.* A new Neutron Generator was designed and built between 1997 and 2002 and first units were supplied to the British in 2003. [liv] The Gas Transfer System is also American. Because Tritium gas is radioactive and can penetrate stainless steel it requires special reservoirs. Because it decays to produce helium, thus increasing the pressure in the reservoirs, it has to be replaced regularly. British tritium is transported as to America as uranium tritide, converted to tritium gas and loaded into reservoirs at the Savannah River site. Both the Neutron Generators and the Gas Transfer System, being limited life items, are replaced on a regular basis. This is done in the Re-entry Body Process Building at Coulport, before the warheads are fitted to the missiles on board the submarines.
The Nuclear Explosives Package is designed and made at Aldermaston. One difference from the American system is that the British use a different high explosive. [lv] No doubt design data were regularly exchanged with the Americans and live testing of British warheads, while this was allowed, took place in Nevada[lvi]. But that does not detract from the British ability to design and build the Nuclear Explosive Package as it exists today.

Can British Trident operate independently of the US?

Under the Mutual Defence Agreement of 1958, co-operation by either party is contingent on its determining that such action 'will promote and will not constitute an unreasonable risk to its defence and security'. The message is clear that such co-operation could be withdrawn at any time if the UK embarked on a course of action that the US regarded as inimical to its interests. The agreement referred to the fact that the two countries were participating in an international arrangement for their mutual defence and security (i.e. NATO) and at Nassau the British Prime Minister accordingly agreed that the strategic missiles to be provided would be used for the nuclear defence of the alliance. It follows that planning for the use of UK Trident is closely co-ordinated both with the American STRATCOM in Omaha and with NATO. A British liaison cell is maintained at STRATCOM.[lvii] The senior US officer in Europe, who is also the NATO commander (SACEUR), allocates targets for British nuclear weapons. The British Commander-in-Chief Fleet is also Commander of Allied Naval Forces North. He is the operational commander of Trident from his headquarters at Northwood, Middlesex. It follows that, so long as British Trident is operated within the NATO context, whether strategically or sub-strategically, no conflict of interest is likely to arise. The question remains whether British Trident could be used without the United States consent and assistance and could be targeted independently of US assistance. When this question was put in the House of Lords in 1995 the Government spokesman replied 'Trident is an independent nuclear deterrent. That means exactly that, I can go no further'[lviii]. The Delphic nature of this response is obviously deliberate.

The issue needs to be discussed at two different levels. If the US were to determine that co-operation on British Trident was no longer promoting American defence and security, or was posing an unreasonable risk to it, then all technical assistance could be withdrawn. Denied help in maintaining, testing and upgrading the missiles, the fire control system and key components of the warhead, and with no re-supply of life restricted items for the latter (tritium injection system and neutron generator) the whole system would become unworkable and probably unsafe within a matter of a year or so. The UK has had no capacity to design and build a missile of strategic range since the demise of the liquid fuelled *Blue Streak* in 1960. To re-create such a capacity would take a decade and the expense would be astronomical. Shopping around for another foreign supplier (Russia, China, North Korea) would be very unattractive, and there would still be the difficulty of fitting the submarines and warheads to fit the new missiles. No wonder the British Prime Minister is at pains to stay on the right side of the American administration where major issues of peace and war are concerned.

Assuming that the system remains functional there remains the question of actually firing a missile in circumstances where the Americans were either neutral or actively opposed. The submarine could presumably be sailed to an area where the sea-bed had been accurately surveyed. The order to fire could be conveyed and authenticated by VLF radio without the submarine either raising an antenna or using an American satellite. The missile would then presumably work, although the accuracy might be impaired if gravitational and weather information, normally

supplied by the Americans, was not available. The unsettling possibility has already been discussed that the software for fire control or in the warhead fusing system might have been secretly doctored so as to require independent US authorization to fire. It is also just conceivable that the Americans, bearing in mind historic suspicions of small independent forces [lix] could have inserted duff components anyway. But these suppositions hardly deserve serious consideration. The reasonable conclusion is that if the British Prime Minister, getting the bit between his teeth, deciding that 'supreme national interests were at stake', regardless of the nuclear taboo and the likely reaction of the entire world (not least the USA), were order Trident to fire then it would do so. Short of attacking the submarine, the communication centre at Skelton or the Prime Minister, there is nothing the Americans could do to stop it.

Future options.

The 2005 election manifesto of the present British Labour Government made clear its commitment to maintaining the UK's 'independent nuclear deterrent'. In amplification the Defence Secretary John Reid has said that a decision will have to be taken in the life of this Parliament (i.e. by 2010 at the latest) whether to 'modify, replace, update or diminish Trident'. [lx] This section sets out some of the technical considerations involved in that decision.

Tim Hare, former Director for Nuclear Policy in the MoD, has argued forcefully that 'more of the same' is the only realistic answer. [lxi] In his opinion the argument for staying with a submarine-launched Trident system is overwhelming, not only on grounds of the operational advantages of stealth and invulnerability[lxii] but equally on grounds of cost. This means keeping the existing system going as long as possible and then replacing it with something as similar as possible - no doubt following the Americans all the way. Such a policy would be wholly within the terms set out by the Defence Secretary for updating, modifying or replacing Trident, probably in that order. The implications of this policy fall differently as between the submarines, the missiles and the warheads. We consider these in turn.

The official life of the British Vanguard class submarines is 25 years. On this basis the first submarine would retire in 2019 and the last in 2024. But compared with normal submarines Trident boats typically operate at somewhat shallower depths, do not experience nearly as many excursions from their normal operating depth, and would not operate below their test depth with any degree of frequency. So it could be expected that they could have a longer operating life than attack submarines. US Navy now assumes that their *Ohio*-class submarines will have an operating lifetime of at least 42 years: two 20-year operating cycles separated by a two-year refuelling overhaul.[lxiii]. One obvious move would be to extend the life of British Trident submarines accordingly: i.e. until 2046 to 2051. One critical factor would be the life of the reactor core. *Ohio* completed 22 years on its first fuel core. The new British fuel core, of which a prototype is being tested at Dounreay, is designed to last 25 years. The predicted life will be adjusted in the light of this test, from inspections during refits and from HMS Vanguard's second visit to Devonport scheduled for 2012. The life of the hull is also critical. Hull and reactor problems affected British Polaris submarines during their later years and there have been a number of serious

reactor defects recently on nuclear powered attack submarines. If the life of British submarines cannot safely be extended it will be necessary to build new boats. It has been announced that both options are being studied.[lxiv]

The Americans have a life extension programme for D5 missiles, with an upgraded guidance system extending their life by 15 years until 2042. The British have apparently no plans at present to acquire the upgraded missiles, but there is no reason in principle why they should not negotiate to acquire these by a further amendment to the Mutual Defence Agreement - at a price.

The largest element of the American nuclear weapons programme is a project to upgrade the W76 warhead. The resulting warheads (W76-1) are due to enter service between 2008 and 2013, with a planned life of 30 years to match the new life span of the submarines and missiles. Most of the British warheads were delivered to the Coulport depot between 1993 and 1998. Since the life of the high explosive is probably about 12 years, a refurbishment programme is probably under way, designed to match the original planned life of the British boats. After that a re-design might well be needed, in line no doubt with the American W76-1, and Aldermaston has carefully nurtured a design team to cope with this requirement. [lxv]

As regards 'diminishing Trident' there should be no difficulty. Under the more relaxed post-cold war conditions a fleet of three boats might be sufficient. The rationale for keeping a stock of 58 missiles and 'under 200' operationally available warheads has never been explained. A discussed earlier there would be no difficulty in operating a submarine on deterrent patrol with fewer than 8 missiles on board and fewer than 4 warheads on each.[lxvi] Although this might not save much money, this would enable the British government to show further progress towards nuclear disarmament, as treaty commitments require.

One possible alternative to Trident would be to acquire the American sea-launched cruise missile in its nuclear version, Tomahawk Land Attack Missile - Nuclear (TLAM-N). Conventionally armed versions of the same missile were fired from submarines and surface ships in attacks on Iraq, Afghanistan, Serbia and Sudan. Britain deploys these on some submarines and plans to equip all attack submarines with them in due course. TLAM-N was introduced into the American fleet in the 1980s [lxvii] and it has been suggested that Britain might deploy them on *Astute* class submarines as an alternative to Trident. This would involve a huge reduction in firepower in comparison with Trident, the purchase of a new missile system, a new design of warhead and support facilities and no doubt heavy costs.[lxviii] Moreover there is every sign that the US Navy is unenthusiastic about TLAM-N and may shortly begin to phase them out.

A third alternative would be transfer the nuclear strategic role back to the RAF, perhaps by fitting a nuclear warhead to missiles carried on the new Typhoon aircraft. In the 1980s Britain had considered such a project as a tactical weapon instead of free-fall bombs. One possibility was to acquire the American missile known as Short Range Attack Missile - Tactical (SRAM-T) which was to use an existing nuclear warhead. Another idea was to combine with the French, using their missile Air-Sol Longue Portée (ASLP). In the early 1990s both these projects were cancelled, but not before a British warhead had been designed for this purpose.[lxix] At present there is no

American project on these lines and the prospect of a go-it-alone British version is al but negligible.
It seems, therefore, that Tim Hare's view is likely to be vindicated, subject only to a plan being devised at an acceptable cost. With programmes for future aircraft carriers, new frigates and Astute Class submarines all in the pipeline the naval budget will be under unusual stress in the near future. Much will depend on the price tags that emerge from present studies and until these are available further speculation is unprofitable.[lxx]

Acknowledgement.
The writer acknowledges his immense debt to the prodigious research carried out by John Ainslie for his Report 'The Future of the British Bomb'. Material from that report, and more particularly references, are to be found on every page of this chapter. To acknowledge these ascriptions individually would be vexatious so this more general acknowledgement must suffice.

References

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[i] See http://www.devonport.co.uk/about-toplevel.htm HMS Vanguard was refitted between February 2002 and January 2005. HMS Victorious then began refit.
[ii] Spearfish is a wire guided torpedo with both active and passive homing and a range of 65km.
[iii] The latest development of PWR would allow submarines to circumnavigate the earth 40 times without re-fuelling.
[iv] This presumably means that no targets have been pre-loaded onto the missiles. The Defence Secretary is on record that 'missiles can be targeted in sufficient time to meet any foreseeable requirement' (House of Commons Hansard Written Answers for 27 Oct 2005. No. 21903).
[v] A telescoping outward extension that halves frontal drag.
[vi] Say, ten times faster than Concord.
[vii] For the US, START I treaty agreements limit this to eight.
[viii] All the aim-points, however, must lie within an ellipse called a 'footprint'. Its size depends on the range and loft of the missiles' trajectory and will be measured in hundreds of nautical miles
[ix] These consist of dummy RVs designed to give the same radar signature (size and speed) as real ones, and chaff to blanket radar transmissions.
[x] It can be checked by GPS, but this requires an aerial to be raised above water which could compromise the submarine's position, and in war the satellites might already have been knocked out. If operating in a pre-surveyed area, bathymetric data can provide an additional fix.
[xi] This allows both for the variations in the earth's gravity due to its not being a perfect sphere and for the gravitational effects of the moon.
[xii] Also confusingly known as the UK Trident Re-entry Body (RB). Its alphanumeric code name has not been released.
[xiii] This figure has never been officially confirmed for British Trident, but appears to be generally accepted as accurate.
[xiv] Public Records Office, Operational Selection Policy, OSP 11. Nuclear Weapons Policy 1967-1998.
[xv] A reasonable guess would make it 6 feet long with a base diameter of about 2 feet.
[xvi] In American English the word 'pit' means the stone of a fruit.
[xvii] This shell, which can also consist of uranium or tungsten, is usually known as the 'tamper'.
[xviii] One nano-second equals one billionth of a second.
[xix] The nucleus of an atom of hydrogen contains one proton: the nucleus of Deuterium contains a proton and one neutron: Tritium has a proton and two neutrons.
[xx] Also known as a 'tamper'.
[xxi] Rather misleadingly this is normally known as the 'Spark Plug'.

[xxii] The largest thermonuclear explosion ever created by man was the Tsar-Bomba detonated by the Soviet Union in October 1961. This had an explosive yield of 50 megatons and the entire fission-fusion process lasted only 39 nanoseconds.
[xxiii] Confirmed most recently by Defence Secretary John Reid in October 2005. See the Written Answer quoted in note iv above.
[xxiv] Given that the US is required by the START I Treaty to put no more than 8 warheads on each missile, the latter loading (4x12) is ruled out for American Trident and is therefore most unlikely to have been adopted by the British.
[xxv] 'UK Defence Strategy: a continuing role for nuclear weapons?' Speech to the Centre for Defence Studies, London. 16 November 1993.
[xxvi] Rear Admiral Irwin, MoD Chief Executive, Strategic Systems, in remarks made to the Defence Committee, said that a missile with a single warhead could be used in either a sub-strategic or strategic role. 'Progress of the Trident Programme'. 2nd Report of the Defence Committee, 1993-4. 4 May 1994. HC 297, p.26.
[xxvii] Commander Tom Herman, 1 Submarine Squadron, Navy News Clyde Supplement, May 1996.
[xxviii] 'The UK has some flexibility in the choice of yield for the warheads on its Trident missiles'. Defence Secretary George Robertson in the House of Commons. Hansard, 19 March 1998, column 724.
[xxix] As in note xxii. p.6.
[xxx] As in note xxii.
[xxxi] One speculation, by the Bulletin of Atomic Scientists, runs as follows: 'Some Trident II SLBMs have a single warhead and are assigned targets once covered by WE177 gravity bombs. For example, when the *Vigilant* is on patrol, 10, 12, or 14 of its SLBMs may carry up to three warheads per missile, but the other two, four, or six missiles may be armed with just one warhead' . See http://www.thebulletin.org/article_nn.php?art_ofn=ja99norris
[xxxii] Polaris missiles in the first instance. These were replaced by Trident missiles in the 1990s as explained above.
[xxxiii] The text of the Nassau agreement was given in the White Paper Cmnd, 1915 and published in *The Times,* 22 December 1962.
[xxxiv] Ministry of Defence, Strategic Defence Review, July 1998, para. 55.
[xxxv] The exact wording is 'source, by-product and special nuclear material, and other material for research on, development of or use in atomic weapons, when the Government of the United States ... determines that the transfer of such material is necessary to improve the United Kingdom's atomic weapon design, development or fabrication capability'.
[xxxvi] 1958 Atomic Energy Agreement . *UN Treaty Series,* 1959, Vol. 326, No. 4707, pp. 4-20
Amendment. *UN Treaty Series* 1960, Vol. 351, No. 4707, pp. 458-464.
[xxxvii] Message to Congress from President Bush, 14 June 2004. See http://www.whitehouse.gov
[xxxviii] The main difference is the Trident submarines have 16 missile tubes while the Ohio Class has 24.
[xxxix] The barter also included the transfer of some 6.7 kilogrammes of tritium from the US to the UK. (Information release by the US Department of Energy, 22nd December 1997).
[xl] See http://tx.mb21.co.uk/features/skelton/index.asp
[xli] This would not, of course, apply to Trident used in a sub-strategic role.
[xlii] Satellite Communications Acquisition IPT. IPT 133. www.mod.uk/linked_files/dpa/satsynop2.pdf It is known that this system is being acquired for British Astute Class submarines, but it has not been announced whether this system will also be used on Trident boats
[xliii] This will be fully compatible with GPS, and will provide world-wide cover, giving accuracy within one metre, readable by a small cheap individual receiver.
[xliv] With current ship-based methods it would apparently take 200 years to survey the bed of all the oceans n the world.
[xlv] Defence Secretary John Reid, House of Commons Hansard Written Answers for 27 Oct. 2005. [21902]
[xlvi] www.subasekb.navy.mil/TRIDENT%20REFIT%20FACILITY/MISSION.htm This web site claims that the Trident Refit Facility provides 'total integrated logistical supply support to attack and UK submarines' including degaussing services.
[xlvii] See
http://www.lockheedmartin.com/wms/findPage.do?dsp=fec&ci==12336&rsbci=0&fti=0&ti=0&sc=400=fec&ci&prfr=true

[xlviii] See http://www.jhuapl.edu/newscenter/aplupdate/pdf/up001017.pdf

[xlix] At a cost of some $47m. Adam Ingram, Armed Forces Minister, in House of Commons Hansard, written answer, 18 June 2004

[l] Originally California Analysis Centre Inc.

[li] CACI News Release, 10 May 2002

[lii] For 'Insert Word' message see under 'Target Planning and Fire Control' above. The contract reference is 'FY05 Mod5 UK Intent Word Displays, Award N0030002G0054NJ72'

[liii] http://www.awe.co.uk/main_site/about_awe/ click on logo for AWE's Annual Report 2004. pp. 4-5.

[liv] http://www.sandia.gov/LabNews/LN03-07-03/LA2003/la03/nuclear_story.htm

[lv] The British explosive, known as EDC37, has the same base explosive but in finer particles and a softer binder. This means that the way the primary operates will not be identical and separate safety assessments are needed of responses to shock and heat.

[lvi] For 30 years between 1962 and 1991 British scientists conducted 24 nuclear tests with their U.S. colleagues at the Nevada Test Site.The last live test of a British warhead took place on 26 November 1991. www.thebulletin.org/article_nn.php?art_ofn=nd05norris

[lvii] 'We have declared the strategic system to NATO and we plan and de-conflict our NATO plans with the targeting centre in Omaha'. Admiral Irwin. 'Progress of Trident, 6th Report, Defence Select Committee1993, HC549, minutes of meeting 10 March 1993, Para. 1573.

[lviii] Lord Henley. House of Lords, 11 January 1995.

[lix] c.f. Defence Secretary Robert McNamara in 1962 who declared such systems to be dangerous.

[lx] House of Commons Hansard, 6 June 2005, [1925], Col. 987

[lxi] Tim Hare, 'What next for Trident?', *RUSI Journal* April 2005, pp. 30-33.

[lxii] The Royal Navy claims that a British submarine on deterrent patrol has never been detected.

[lxiii] http://www.fas.org/nuke/guide/usa/slbm/ssbn-726.htm

[lxiv] Defence Secretary Geoff Hoon, House of Commons Hansard, written answer, 30 June 2004.

[lxv] Facilities at Aldermaston and Burghfield are being upgraded at a cost of £350m. for each of the next three years. Ostensibly this is to provide assurance of continued reliability and safety for the existing warhead stock, since live nuclear testing is no longer allowed under the Comprehensive Test Ban Treaty, of which the UK is a party. But it also helps to keep the British up to speed *vis-à-vis* the Americans in the art of new warhead design.

[lxvi] This could go as low as one missile carrying one warhead, by way of *reductio ad absurdum*!

[lxvii] Some 367 missiles in all.

[lxviii] Tim Hare, as in footnote lx above.

[lxix] There is evidence that the last three live nuclear tests of British warheads were for this project, not Trident.

[lxx] According to John Ainslie a complete rebuild of a Trident like system would cost over £15bn at present prices. This sounds on the cheap side. Each individual submarine would cost more than£1bn. 'The future of the British Bomb' published by the WMD Awareness Programme October 2005. p. 26.

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then filter for

If record is found check contact details and tick Elist boxes
for which email says "on"

If record is not on database create a new record using ">*" at the bottom of the main form.

Remove filter using Record/Remove filter

Move messages done to Topics/Email lists/messages on dbase folder

Unsubsciptions

Find record as above

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