The Future of the British Bomb

John Ainslie

SPOKESMAN

"for the sake of humanity - we must get rid of
all *nuclear weapons"*

Professor Joseph Rotblat (1908 - 2005)

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Purpose
The purpose of this report is to contribute to a comprehensive debate on the future of British nuclear weapons. The intention is to identify and clarify key issues from a perspective of opposition to the bomb. The report brings together technical information on Trident and nuclear planning systems in order to understand the current situation.

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Summary

A decision on the future of British nuclear weapons will be made before 2010. The last parallel to this situation was in the late 1970s. This new opportunity to make progress towards disarmament should not be missed. A full and open debate is essential.

Dependence

There are both political and technical reasons for concluding that the concept of the British independent deterrent is a myth. There are arrangements for incorporating British weapons into the US plan for strategic nuclear war. Plans for a more limited joint attack can be created at short notice. But it would be almost impossible to carry out a strike against US wishes. British nuclear weapons are more likely to be used in a bilateral US/UK operation than independently or under NATO command.

The warheads on Royal Navy submarines have an American design. Several crucial components are built in the US. They are Anglo-American rather than British. American support is essential for all aspects of the British Trident system, even where it is distinct from the US version. Reliance on American software for all aspects of targeting undermines nuclear independence. Any future British nuclear weapons system will only be as independent as Washington wants it to be.

Why does Britain need nuclear weapons ?

British nuclear forces are still sized for an attack on Russia although the country is not regarded as a threat. There is deliberate ambiguity over whether they have any role to play in countering the proliferation of Weapons of Mass Destruction. A threat to use them in response to a chemical or biological threat would not be credible. Nuclear weapons are of no help when it comes to responding to terrorism. Al Quaeda might deliberately provoke a nuclear attack.

There appears to be no enthusiasm within the British nuclear establishment for the US warfighting approach. Senior figures have dismissed concepts of very low yield and “useable” weapons. The Nassau Agreement only permits independent use where supreme national interests

are at stake. Trident could not be used independently to promote wider British interests. There is however a danger that British forces could be drawn into a US nuclear operation.

It has been suggested that British nuclear weapons bring a number of political benefits, but these arguments are hollow. In the special relationship with America other issues are more important than nuclear weapons. Nuclear status is not a key issue determining membership of the UN Security Council today. The French bomb is not a serious factor. Trident is not an efficient job-creation scheme.

There is no evidence to support the thesis that nuclear weapons prevent war. There have been millions of victims of war in the nuclear era. The efficacy of deterrence cannot be measured. It assumes an unrealistic capability to understand the thinking of the adversary. US planners acknowledge that deterrence theory may not apply to future threats. There is no realistic scenario where British nuclear weapons could contribute to preventing war.

Any country could argue that it needs nuclear weapons to deal with the long-term uncertainties of the future. Many could present more convincing arguments than Britain. It might be difficult to restore the bomb once it was lost, but this is no argument for keeping it, particularly if there is a genuine desire to fulfil the requirements of the Non Proliferation Treaty and make progress towards disarmament.

There is no justification for retaining nuclear weapons so long as any other country has them. The taboo on nuclear use is the main restraint preventing any country from launching a nuclear strike. It would be strengthened if Britain moved towards relinquishing our nuclear arsenal. Britain's nuclear weapons encourage others to have the bomb and hinder attempts to tackle proliferation. They contribute to the complex relationships between the forces of existing nuclear powers. Implementing British nuclear plans during the Cold War would have been in breach of the Geneva Convention. Retaining these weapons for decades to come would undermine attempts to promote international law.

Deterrence has always included making meaningful preparations to use nuclear weapons. Its political and military aspects cannot be separated. In a crisis, leaders often make the wrong decision because of human error and poor intelligence. It might never be rational to use nuclear weapons, but that does not mean that they will not be used. An attack with the warheads on one British submarine would leave at least 3 million people dead. Deterrence theory is a stumbling block preventing steps that would reduce the risk of an accident.

It would cost billions of pounds to upgrade Trident and even more to build a replacement. Over several decades the running costs would be even more than the initial capital expenditure.

Aspects of British nuclear policy

Uncertainty is at the heart of British nuclear thinking. Secrecy is not an aspect of the policy - it is the policy. There is a substantial element of bluff in any threat to use nuclear weapons, but the stakes are very high in the nuclear game. "Minimum deterrence" in practice has meant convincing Washington that Britain has the capability to launch a crippling attack on Russia. Invulnerability will be a key issue in the internal review of options. Those who wish to retain a submarine-based force will argue that it is essential. With invulnerability comes the maintenance of a constant threat to others. Since the 1960s British planners have considered using a few lower yield weapons in a pre-strategic role to warn that this country was prepared to launch a massive nuclear attack.

Nuclear Options

The MoD is likely to focus on finding a way to continue deploying Trident missiles for as long as they are in service with the US Navy, which is planned to be until 2042. The life of existing submarines cannot be reliably extended for a long period. Building new submarines will be high on the agenda. If the life of Trident were extended then a second round of warhead refurbishment or the development of a replacement would be required. The upgraded warheads could be different from than those currently in service.

The US Navy does not currently deploy nuclear-armed sea-launched cruise missiles. These weapons are likely to be phased out. The obsolescence argument that led to the US and Britain abandoning tactical air-to-surface nuclear missiles applies even more today. Freefall bombs would be vulnerable to modern air defences. Borrowing American nuclear bombs would acknowledge the reality of dependence.

If Britain continues to have nuclear weapons then a new tritium processing plant will be built. If nuclear-powered submarines are retained then more HEU will be enriched, in the US, for submarine fuel.

While there have been allusions to a range of reasons why Britain needs the bomb, none of the rationales stand up to close scrutiny. A decision not to replace Trident would bring substantial financial and diplomatic benefits. This country should not squander its resources and international status just so that one day we can join in a foolhardy American nuclear adventure.

Summary of annexes

A. US nuclear policy

The main focus of the US nuclear programme remains Russia. In addition a "to whom it may concern" aspect has been added. With regard to this second role, ambiguity is deliberately promoted. It is argued that in the new situation deterrence is more likely to fail. An ability to launch a strategic strike against any target in the world at short notice is being sought. For such an attack, the B2 stealth bomber would be the weapon of choice. There is growing emphasis on China. US planners now acknowledged that they could use nuclear weapons in a pre-emptive strike.

More useable weapons have been advocated. This is a dangerous and flawed approach. International condemnation of any US nuclear attack would be such that a threat to use a lower-yield weapon would still not be credible. Any nuclear weapon that was able to destroy a deep bunker or missile silo would produce a large amount of fallout.

B. NATO nuclear policy

The central tenets of NATO nuclear doctrine were created during the Cold War. The US would like NATO to adopt its view that nuclear weapons can be used for counter proliferation, but many of the allies have been reluctant to accept this.

C. British nuclear planning system

There are special arrangements for distributing highly classified US nuclear planning information to Britain. Computers in the Nuclear Operations and Targeting Centre in London create target plans for Trident. The targeting process involves drafting plans and formatting tapes on shore, then processing data on the submarine. At each stage the software is American.

D. US nuclear planning system

The main task of the computer system at Omaha is the annual revision of the main nuclear attack plan, which is primarily focused on Russia. The system is being substantially revised to make it more flexible. This will increase the effectiveness of an attack on Russia with fewer weapons. It will also enable any weapon in the US arsenal to be used against any target around the world, at short notice. This is a significant enhancement of US nuclear forces.

E. NATO nuclear planning system

NATO has said that it no longer maintains nuclear attack plans. It does have a system that can rapidly create such plans. The new flexible system is closely integrated into the main US hub at Omaha. It is a system for planning attacks with Dual Capable Aircraft. There is a sub-system that handles nuclear consultation between the allies. This will deal with Trident missions as well as bombing sorties for aircraft.

F. Trident Targeting and Fire Control

In 2003 there was a significant enhancement of Trident. New computers were installed on American and British submarines. As a result the missiles can now be rapidly retargeted. This project was started in order to make an attack on Russia more effective. It also makes it easier to use Trident against new targets around the world. Target planning for Trident is complex. Submarines can only launch from areas of ocean for which special maps have been produced. Without gravity and weather data, produced in the US, the missiles would be less accurate.

G. Communications to British Trident

Messages can be sent to British submarines using British, American and NATO satellite and VLF/LF systems. In future the most important frequency for US nuclear communications will be EHF. Communications to British Trident submarines on EHF will use an American satellite.

H. Modes of use of Trident

Trident was designed for a situation where all the missiles on a submarine are fired at once. Both US and British systems make provision for a more limited use of Trident. The US Navy can use a small number of missiles in a theatre nuclear operation. Britain has missiles armed with single warheads but probably does not have a lower yield variant of Trident. This could be developed in future if Trident was made more accurate. A US research project to increase Trident accuracy recently stalled when Congress withdrew the funding.

I. US W76 warhead and UK Trident Re-entry Body

Britain has taken advantage of a relatively minor upgrade of the Trident warhead and incorporated new neutron generators off-the-shelf from the US. A more substantial upgrade, W76-1, of the weapon is underway in America. W76-1 will be more capable than the current warhead. It will have a new arming, fusing and firing system with a contact fuse. This will mean that the same number of targets can be destroyed with fewer warheads. It is likely that Aldermaston wants to incorporate these new features in a refurbishment when the warheads reach the end of their planned life, from around 2017. Alternatively there could be a more substantial re-design within this timescale. The warheads on British submarines use a different High Explosive. This means that many key calculations for the American warhead cannot simply be duplicated. US support is crucial for this additional work.

J. Nuclear weapons development process

There is an extensive, but not unlimited, exchange of nuclear weapons' information between the US and Britain. The US is building the largest computers in the world, not to predict tsunamis or hurricanes, but to design nuclear weapons. While the initial focus is on upgrading existing warheads these facilities could later be used to design new bombs. There are parallel developments in Britain. The Government have announced that £1 billion will be spent on new facilities at Aldermaston. These are likely to be used initially for the existing Trident warhead but could be used, in the longer term, to design a new warhead.

K. US and NATO Dual Capable Aircraft

The US retains 480 nuclear bombs in Europe, some of which can be used by aircraft from four allied nations. The most significant base is at Lakenheath in England. For their nuclear role the aircraft are now on a reduced alert state, measured in months. US military commentators have argued that it would be safer if the bombs were stored in America, and that they have no conceivable military or deterrent role. They are no more than a dangerous legacy of the Cold War.

Introduction

The need for a decision

The Defence White Paper in December 2003 reported that, while a decision on whether to replace Trident would not be needed in the lifetime of the current parliament, it was expected during the next parliament. This was repeated in subsequent statements. On the eve of the 2005 General Election the Independent reported that the decision to replace Trident had already been taken. In June 2005 the New Statesman said the matter was already a done deal – the decision had been taken to replace Trident, all that remained was to choose which system should be adopted.[1] In its election manifesto the Labour Party said they were committed to retaining the independent nuclear deterrent. It is not correct to deduce from this that the replacement decision has already been made. The statement in the manifesto was a repeat of the established position, not the result of any major review. The Defence Minister, John Reid, said in July 2005 that he had not yet begun to consider the issue. In September 2005 he was reported as opening the debate on the issue.[2]

Some commentators have argued that there is no need for the decision to be made in the life of this parliament. Lord Garden, Liberal Democrat defence spokesperson, has said that there is still substantial life left in the Trident system and that the issue will not need to be tackled before 2010.[3] The timescale may be determined by the expected life of Trident submarines. The official hull life of each vessel is 25 years and the first submarine, HMS Vanguard, will reach this in 2019. The warheads will need to be either refurbished or replaced from around 2017.[4] A new submarine or an alternative system would require a long lead-time. A review is likely before 2010.

The decision making process

Resolution class submarines had an initial life expectancy of 20 years. In 1977, eleven years before the end of this planned life, a sub-group was set up to consider a replacement for Polaris. At the time it was anticipated that the life of the system could probably be extended. The sub-group, consisting of the Prime Minister, Chancellor, Foreign Minister and Defence Secretary, established two working groups of officials: one, led by the Foreign Office, looked at military and international implications, the other, led by the MoD, looked at alternative systems. Two studies were presented to ministers in November 1978. It was agreed that a decision should be taken before the end of 1980 and that the replacement was likely to be a submarine-based system.[5] Jim Callaghan raised the issue with President Carter in January 1979. His successor, Mrs Thatcher, set up Cabinet subcommittee MISC 7 and reached agreement with President Regan in 1980. The Defence Select Committee examined the future of strategic nuclear weapons after this decision had been made. The initial proposal, to acquire Trident C4, was revised in 1982 and the D5 system was procured. The first Trident submarine entered service in December 1994.

Opening a conference on the Future of Strategic Deterrence for the UK, in July 2005, Rear Admiral Richard Cobbold, Director of the Royal United Services Institute, said, "momentous decisions of this kind should not be made behind closed doors."[6] The issue is significant not only in defence terms, but also because of its financial, diplomatic and moral implications. There should be break from past practice, a meaningful process of consultation and proper Parliamentary scrutiny.

In order to address the fundamental issue of what British nuclear weapons are for, it is important that the review looks beyond the question of whether to extend the life of Trident or replace it with some alternative. It must fully consider the non-nuclear alternative.

Nuclear independence

The special relationship

France has developed a range of nuclear capabilities with limited assistance from America. It has tried to retain not only operational independence but also nuclear self-reliance. Belgium, along with Germany, Italy and Holland, has aircraft that could be armed with US nuclear bombs. American forces secure the weapons and keep the codes needed to arm them. Britain's nuclear capable forces are more independent than those of Belgium and less independent than those of France.

The US has provided Britain with information on nuclear weapons, a range of essential hardware and assistance with nuclear material. In return British nuclear forces are constrained by two agreements. The Mutual Defence Agreement of 1958 says that the information and material provided by the US can only be used for mutual defence purposes. The Polaris Sales Agreement, reached in Nassau in 1963, says that British nuclear forces are assigned to NATO, except "where her Majesty's Government may decide that supreme national interests are at stake".[7]

Sir John Slessor, Chief of the Air Staff criticised the decision to buy Polaris. He condemned the way the agreement had been reached and the role of the Chief Scientific Adviser, Solly Zuckerman, whose background was in zoology. Sir John said, "It is a really appalling thought that a couple of Ministers and a zoologist can slip off to the Bahamas and, without a single member of the Chiefs of Staff Committee present, commit us to a military monstrosity [ie Polaris] on the purely political issue of nuclear independence – which anyway is a myth."[8] His statement was influenced by his own desire to resurrect the abandoned Skybolt system, nevertheless it revealed an awareness, at the highest levels, of the reality of nuclear dependence. Field Marshall Carver later argued that there was no point in Britain having an independent nuclear capability.[9]

It is almost inconceivable that the US would be neutral about a British nuclear strike. Any such attack would be so critical that the US would have a view about it. There are two types of situation in which British nuclear weapons might be used: where the action would be supported by the US and where it would be opposed by the US.

There is no doubt that British nuclear weapons could be used if London and Washington were in agreement. British weapons have almost certainly been incorporated into US nuclear attack options. An attack plan created in London would receive valuable practical support from the US Navy and Strategic Command (STRATCOM), if Washington endorsed it.

The critical issue is whether Britain could use its nuclear forces in a situation where the US was opposed to their use. If America objected then the attack would not be in both parties interest and would be in breach of the Mutual Defence Agreement. The US would be likely to use strong-arm tactics to dissuade Britain from acting. The technical dependence, outlined below, would constrain any independent attack.

Behind the scenes the US has not always been fully supportive of the British nuclear force. The McMahon Act (1946) restricted nuclear co-operation for a decade. Prior to the Nassau Agreement President Kennedy drafted a letter saying that he hoped to use his influence “in the direction of a gradual phasing down of the British nuclear commitment”.[10] A few years later the State Department briefed President Johnston to urge the new Prime Minister, Harold Wilson, to implement his party’s commitment to nuclear disarmament.[11]

In the Cold War British nuclear weapons could have acted as a catalyst, drawing the US into a European nuclear conflict. Today American planners are worried that the US could unwittingly be pulled into a nuclear war because of the actions of Israel.[12] They are aware of the potential dangers from friendly nations with nuclear weapons. Robert O’Neill, former director of the International Institute of Strategic Studies, has said, “I suspect the United States would secretly be quite relieved if Britain were to give up its nuclear weapons”.[13]

The independence of British nuclear weapons has been stressed partly because of domestic political pressure. The drafting of the Polaris Sales Agreement was an example. Harold McMillan sent the wording, which he had agreed with John F Kennedy in Nassau, to London for the rest of the Cabinet to consider. They insisted that independence had to be clearly spelt out and that the reference to independent use be placed before the phrase saying British nuclear weapons were assigned to NATO.

The Strategic Defence Review (1998) said, “The United Kingdom has committed all its nuclear forces, both strategic and sub-strategic to NATO”.[14] This has long been a feature of British nuclear policy. In the early years nuclear co-operation was largely bilateral. In 1957 Britain agreed to host Thor missiles, but insisted that they came under a dual-key US/UK system rather than NATO control. In the 1960s Washington sought to establish a multilateral NATO nuclear force. They proposed manning

Polaris submarines with crews from several countries. Britain insisted on an arrangement that was, in practice, bilateral.

Today, although the US is keen to use NATO in as many situations as possible, it does not want to be constrained by the views of its allies. As Donald Rumsfeld said, "The mission must determine the coalition, and the coalition must not determine the mission".[15] The US was unable to use NATO for the invasion of Iraq and so created a new coalition, with Britain as the key supporter.

NATO nuclear operations are subject to the consultation process of the alliance. This may be regarded as an unnecessary hurdle. The importance of the "assignment to NATO" of British nuclear forces is exaggerated. Britain is more likely to use nuclear weapons in a bilateral Anglo-American operation than either under NATO auspices or as an independent force.

Although existing alliances may not always be used, the US is aware of the value to be gained by involving other countries.[16] British nuclear weapons could be used as a substitute, a proxy, for US weapons. This might happen if America was unwilling to face the consequences of launching a nuclear attack, but was able to persuade Britain to act on their behalf. A more likely scenario is that a few British weapons could be used in support of a larger US nuclear strike. A small proportion of the conventional cruise missiles fired at Yugoslavia and Iraq were launched from British submarines. The US might persuade Britain to play a similar role in a nuclear attack. The object could be to legitimise an aggressive American nuclear attack and to share the blame for it.

The threat or use of British Trident in a bilateral operation could be divisive for NATO. For this reason it is likely that both London and Washington are reticent about any plans for attacks of this nature.

Technical dependence

The Government acknowledge that Trident missiles are leased from the US but claim that they carry British warheads. This description is questionable. The warhead is a Dutch copy of the US W76. A report by the Public Records Office refers to the Anglicisation of an American design. Several key components are produced in America. The warheads on Royal Navy Trident submarines could be more accurately described as Anglo-American rather than British.

The Neutron Generator is one vital part. It contributes to the initiation of nuclear fission. The MC2989 Neutron Generators initially deployed on British warheads were overhauled in the US in 1999. This implies that they were built there. A replacement Neutron Generator, MC4380, was manufactured in America and supplied to Britain in 2002. The Gas Reservoir in the warhead supplies tritium to boost the fission process. The reservoirs on British warheads are filled with tritium in the US. These are difficult components to build. This suggests that the reservoirs in British warheads are manufactured in America. The Arming, Fusing and Firing System triggers the warhead. The model used on British warheads was designed by Sandia Laboratory and almost certainly procured off-the-shelf from America.

The Trident system operated by Britain is not identical to that deployed by the US Navy, although it is very similar. One difference is the type of high explosive in the British warhead. US nuclear weapons laboratories are playing a critical role in assessing the long-term performance of this British explosive. A second difference is the Fire Control System. British submarines carry a slightly different model. But all the hardware and software for it is created in America. It is significant that, even where the British Trident system differs from the American version, US support is essential.

The US role in handling tritium and making the Neutron Generators is known from publicly available American sources. Yet when asked about these issues in Parliament the Defence Minister refused to answer, on grounds of national security.[17] Successive governments have withheld information to conceal dependence. There is a deliberate attempt to create ambiguity over the extent of dependence. The true limitations of independence are concealed. This is consistent with the policy of uncertainty that lies at the heart of British nuclear policy.

Reliance on American support is not only of historical and current significance. It will remain a crucial factor so long as Britain remains a nuclear-weapons state. The terms of the Mutual Defence Agreement constrain how information and material that has been exchanged can be used. The British nuclear weapons establishment today is almost entirely dependent on this information. Any future nuclear programme will build on what exists today. It will be subject to the same limitations and must be in the mutual defence interest of both Britain and the United States.

A truly independent nuclear weapons programme is not an option. A future system might be more or less dependent on US support than at present. Current and future US Administrations will determine the degree of independence. Also, the US can probably restrict the independence of the system in service, should there be a change in policy in Washington.

Targeting systems

In 1988 the National Audit Office reported that it was essential that Trident targeting software be produced in Britain. As Trident entered service it was revealed that “contractor support” had been required to complete this work. This contractor support almost certainly came from the US.

Targeting data on British Trident submarines is processed in the Fire Control System by software produced in America. This data is created in the Nuclear Operations and Targeting Centre in London. The centre relies on US software. In 2002 the Fire Control Systems on British and American Trident submarines were modified. Just before this the computers in the London targeting centre were upgraded.

The American applications used for target planning and for fire control are complex and unique. It would be possible for US programmers to modify the software supplied to Britain, either openly or covertly, to restrict how Trident could be used.

Even those who operate the system may not have an accurate perception of its dependence. The British Trident system is only as independent as Washington wants it to be. It could be argued that constraints on independence would be consistent with the Mutual Defence Agreement.

British warheads can be integrated into US attack plans. There are special arrangements for supplying US nuclear targeting information to Britain. The United Kingdom Liaison Cell at STRATCOM headquarters in Omaha plays a central role this process. US support may also be required to produce plans for an independent attack.

The NATO Nuclear Planning System is a mechanism for preparing attacks by nuclear-armed aircraft. The crucial systems for targeting Britain’s Trident force are bilateral. While there will be links between the British system and NATO headquarters, the essential networking is between London and the headquarters of STRATCOM. The instructions to order the use of British weapons are not issued in the form of NATO Emergency Action Messages, but through a unique system.

Trident missiles can only achieve the required level of accuracy if a special forecast of the weather over the target is available. This is supplied to British and American submarines in compressed messages transmitted every 12 hours by the US Navy. Trident also relies on gravity information from US sources. Without this weather and gravity data the missiles would be less accurate.

British Trident submarines are normally on a state of alert measured in days. There is a substantial American presence at the Northwood headquarters from where British submarine operations are controlled. If the alert state of British Trident were raised, the US would almost certainly know. This would give them several days' notice of any British nuclear attack.

Communications with British Trident submarines can be made through British or NATO systems. In addition there are bilateral systems. These are likely to be used for key data. Submarines can receive messages on a wide range of frequencies. In future it will be possible to use Extremely High Frequency (EHF), but only through a transmitter on an American satellite. EHF is important because it is considered to be less vulnerable than other systems during a nuclear war.

Why does Britain need nuclear weapons?

Russia

Within the US nuclear establishment there is an ongoing emphasis on Russia, partly concealed by rhetoric about new wider threats. While there have been demands to design lower-yield weapons, the vast bulk of the US nuclear budget is spent maintaining the capability to launch a massive attack on Russia.

The essence of British strategy in the Cold War was that London was a second centre of decision-making.[18] The Government was confident that America would come to our aid, but if the Soviet Union mistakenly did not believe this, then the independent British force provided an additional threat. For Soviet planners this "doubles their uncertainty, complicates their planning, and increases their risks".[19]

In the 1980s the Statements on Defence Estimates regularly presented charts illustrating Soviet nuclear forces. In recent years references to Russia's arsenal have been oblique. The Strategic Defence Review said "Very large numbers of strategic and shorter range nuclear weapons, and substantial conventional military capabilities, remain as a potent potential threat to the security of Britain and our Allies".[20] The subsequent New Chapter referred to " the certainty that a number of countries will retain substantial nuclear arsenals".[21] The relevance of Russia remains, behind the scenes, whenever the requirement for a minimum deterrent is mentioned.

Michael Quinlan, while Permanent Secretary at the MoD, gave a speech in Moscow as the Cold War came to a close. In it he argued that relations between Britain and Russia had not reached the point where war was inconceivable. He ruled out any prospect of conflict with France, Germany or Japan as a result of "a long process of patient working together".[22] With regard to Russia "we are not yet at, or even perhaps very near, the point at which the military insurance element becomes entirely irrelevant between us".[23]

Malcolm Rifkind addressed the issue of nuclear weapons in a speech in 1993 when he was Defence Secretary. He said that future policy would "take into careful account what has proved hitherto to be successful in maintaining stability in the presence of Russia's military strength".[24] He argued that maintaining strong military capabilities, including nuclear forces, was an essential basis for building a new relationship with Russia..

Each year US planners revise OPLAN 8044, the blueprint for strategic nuclear war. Its main focus is still Russia. The NATO Nuclear Planning Group has said the alliance does not now have standing nuclear plans. Michael Quinlan has suggested that Britain may no longer have nuclear plans.[25] This would be consistent with NATO's position and could be the case. However there are two reasons to suspect that target plans for British Trident are maintained. Firstly, target data is probably taken onto the submarine before it goes on patrol because submarine communications are vulnerable in a nuclear war. Secondly, the guidelines that establish how information from the US strategic war plan is fed into the British nuclear planning system have been sustained. It is likely that the targeting of British nuclear weapons, particularly with regard to Russia, continues to be coordinated into US plans. In addition British, American and NATO systems have been updated so that nuclear plans can be produced rapidly and weapons retargeted as required.

Russia is not regarded as a current threat or likely to become a future threat. The old enemy is now included on the fringes of NATO through Partnership for Peace. The Royal Navy has assisted in dealing with the disaster on the Kursk and the rescue of trapped submariners in the Russian Pacific fleet. Concern about an invasion of Western Europe no longer dominates British conventional military planning. Yet in the nuclear field it appears that policy makers are reluctant to abandon the past. There is a need to move beyond the cautious views expressed by Michael Quinlan and Malcolm Rifkind in the early 1990s. The timid approach to change can itself be dangerous.

The United States keeps around 480 nuclear bombs in Europe. The debate over the role of these bombs provides an insight into the relevance of British nuclear weapons. Until the late 1980s a large numbers nuclear weapons, of various types, were deployed for use by NATO forces. As the Warsaw Pact collapsed most of these weapons were withdrawn from service but a substantial number of freefall bombs were retained. German, Belgian, Dutch and Italian aircraft could be armed with some of them. Since 2002 these NATO Sub-Strategic nuclear weapons have been on a state of alert measured in months. The presence of the nuclear bombs at eight airbases impedes conventional operations and is a security issue. There is no military argument for their forward-deployment to Europe. Several US reports have argued that these weapons have no military role. They could only be used against an opponent who could not be stopped by conventional forces, but who lacked effective air defences. It is assumed that they have a political role, but this political role is not one of deterrence. The bombs may be a symbol of US commitment to the defence of Europe. They may be place-markers, kept because if they were withdrawn European nations might oppose their redeployment. They may be bargaining chips, held only so they can be negotiated away in a future arms deal with Russia. There are ongoing studies into how these bombs might be used for Counter Proliferation, but a number of US reports conclude that these weapons are not suitable for this role and should be scrapped.

There are two types of NATO Sub-Strategic Nuclear Forces – dual-capable aircraft and a small number of British Trident missiles. Just as there is no obvious role for the US bombs, so Britain's Trident is irrelevant. British nuclear forces, like the dual-capable aircraft, are a relic from the Cold War.

Counter Proliferation

An MoD briefing in 2003 said, "while other countries maintain large nuclear arsenals and the risk of proliferation exists, a minimum deterrent remains a necessary element of our security."[26] Just as the allusion to Russia is vague, so the sense that Trident has a role to play in countering the proliferation of WMD is imprecisely expressed.

In his 1993 speech, Malcolm Rifkind asked the question "To what extent might the United Kingdom's nuclear weapons also have a role in deterring proliferators?"[27] He said the potential aggressor should not be able to completely discount any possibility that Britain could make a nuclear response. However the role of nuclear weapons was far less clear than against the Soviet Union: "There will be more room for uncertainty over the nature and scale of agression that would justify the threat of a nuclear response."

Rifkind raised a key question, which he did not answer - "Would for example, the possible use of chemical or biological weapons against us be seen as justifying the threat of our using nuclear weapons ?" Britain has given Negative Security Assurances not to use nuclear weapons against any nation which had signed the Non Proliferation Treaty (NPT) and which was neither a nuclear-weapon state or in alliance with such a state.

This would rule out the use of Trident in response to a chemical or biological threat in most scenarios. Rifkind posed a second unanswered question – "Would there be any difference between the use of [chemical or biological] weapons against centres of population in the United Kingdom and their use against British forces deployed overseas?" An attack on deployed forces could not be regarded as a risk to Britain's supreme national interest. In this situation, a British nuclear response would only comply with the Mutual Defence Agreement if it had been authorised by NATO. In practice US support would be essential.

David Omand, Deputy Under Secretary of Defence, argued in 1996 that potential enemies should not expect that Britain would always comply with its legal obligations: "I would suggest that a future Saddam Hussein would be unlikely confidently to discount nuclear retaliation by a nuclear power in such circumstances".[28] In 2002, the Defence Minister, Geoff Hoon, said in a TV interview, "if there is a threat to our deployed forces, if they come under attack by weapons of mass destruction and by that specifically chemical, biological weapons, then we would reserve the option, in an appropriate case … to use nuclear weapons."[29] Four days earlier he had made a similar statement to the Defence Committee.[30]

Two contributors to the current debate have questioned the relationship between nuclear and chemical/biological weapons. Tim Hare, a former Director of Nuclear Policy at the MoD, argues that chemical and biological weapons do not have the same potential for devastation or long-term damage as nuclear weapons. Lumping all three together as WMD is not helpful.[31] Michael Clarke says "There is no comparison between the strategic deterrent power of nuclear weapons on the one hand and of chemical and biological weapons on the other".[32]

A nuclear response to a chemical or biological attack would be a major escalation of any conflict. The response would be so disproportionate and clearly illegal that a threat to make it would scarcely be credible. The statements made by David Omand and by Geoff Hoon are worrying. However, they appear to include a substantial element of bluff.

US nuclear policy is more clear-cut. The new US nuclear doctrine makes it plain that nuclear weapons could be used in response to a chemical or biological threat. It also says that America could launch a pre-emptive nuclear strike. In such cases the US would be likely to put pressure on Britain to join in. A British nuclear contribution would not be militarily necessary. There would be technical obstacles to using Trident.[33] But with British involvement a nuclear strike could be described as a joint or coalition operation.

Terrorism

Terrorism is considered to be the main threat to security today. There is a possibility that a terrorist group could obtain and use a WMD. However the argument that our own WMD have any role to play in countering this danger is false. Nuclear weapons could not be used directly against a terrorist group. They would not present an appropriate target. A nuclear weapon would cause widespread damage and would be disproportionate. There is no serious official attempt to argue that nuclear weapons have any direct role to play in the war on terrorism. Trident cannot prevent British citizens acting as suicide bombers.

Both the US and Britain have identified a potential role for nuclear weapons in deterring a state from handing WMD to terrorists. US nuclear doctrine says that adversaries must believe that "transfer of WMD to terrorists will be detected and attributed".[34] But any state handing WMD to terrorists would be aware of the consequences, in terms of a conventional military response, and economic and political reaction. If the assistance were given covertly the nuclear planners in Washington and London would face a major problem. There might be suspicion that a country was behind a terrorist WMD attack, but a nuclear response on the basis of questionable intelligence would not be a sustainable option. Iraq was seen as the prime example - a "rogue" state that might supply chemical or biological weapons to terrorists. However their weapons had been destroyed in the early 1990s and this threat was an illusion. The invasion of Iraq, on the pretence of dealing with this issue, has increased the terrorist threat.

Michael Clarke has argued that the possession of nuclear weapons, far from discouraging terrorism, may result in deliberately provocative terrorist violence. Suicide bombers might try to provoke a nuclear response. Osama bin Laden would be more likely to encourage an Anglo-American nuclear attack, than be deterred by the threat of one.

Warfighting

The US Nuclear Posture Review (2001) promoted "useable" nuclear weapons. The new American Joint Nuclear Doctrine describes an aggressive nuclear stance, including pre-emptive strikes. STRATCOM acknowledges its warfighting role. Britain could adopt this approach and look on nuclear arms as an extension of the conventional arsenal. There are signs that this approach is not welcomed in London.

Tim Hare says "the UK does not possess nuclear weapons as part of the military inventory, they have no function as warfighting weapons, or to achieve military objectives".[35] He added that US proposals for useable weapons were "highly dangerous thinking". It is likely that this reflects the mainstream view of those involved in British nuclear weapons policy. British thinking is more in line with those within the US military who are critical of the warfighting approach.

Malcolm Rifkind referred to suggestions that very low-yield nuclear weapons might be used in a surgical strike when other nuclear threats would be self-deterring. He dismissed this argument, "the implications of such a development of a new war-fighting role for nuclear weapons would be seriously damaging to our approach to maintaining stability in the European context." Michael Quinlan has said that very low yield weapons undermine deterrence - they were not a sign of resolution, but showed a lack of resolve to use nuclear weapons. Lord Goldsmith's legal opinion prior to the invasion of Iraq showed that Whitehall had doubts about the US doctrine of pre-emption.[36]

Nevertheless the extent of US dominance over all aspects of the British nuclear weapons programme is such that Whitehall may find itself repeating US nuclear doctrine, and in future implementing it.

Protection of national interests

The MoD is sensitive to suggestions that Sub-Strategic Trident might be used in a wide range of situations. A briefing issued in 2003 says that Sub-Strategic Trident does not make "nuclear use easier to contemplate, more likely, or more applicable to action against smaller countries".[37]

Malcolm Rifkind said that Sub-Strategic Trident could be used to - "deliver an unmistakable message of our willingness to defend our vital interests to the utmost".[38] This is primarily based on the British doctrine of a prestrategic warning shot and on the NATO concept that Sub-Strategic Nuclear Forces are the bridge between conventional and Strategic Nuclear Forces. Nevertheless the statement does hint at a wider role for the bomb. The MoD briefing said nuclear forces should provide "the minimum capability necessary to deter any threat to our vital interests."[39]

The term "vital interests" is questionable. The Nassau agreement restricts Britain's ability to use nuclear weapons, out-with NATO, to situations "where her Majesty's Government may decide that supreme national interests are at stake".[40] Threatening to use or using British nuclear weapons in an independent attack to protect interests, other than "supreme national interests", is not consistent with the constraints of the Anglo-American nuclear relationship. This does not mean that British nuclear weapons can only be used in extreme circumstances. They could be used to defend America's vital interests.

Political roles of the bomb

Claims that nuclear weapons serve a political purpose can be ambiguous. On the one hand they allude to deterrence. On the other they suggest that the bomb brings other political rewards. These possible advantages are:

The special relationship with the United States
Britain's nuclear arsenal is claimed to bring with it unique influence within Washington. It is presented as an essential part of the special relationship. The British bomb has been portrayed as a symbol of Europe's contribution to its own defence, to encourage the US to remain committed to European security. Today other factors, such as the British government's support for the war in Iraq, are more significant. The benefit that Britain gets from proximity to Washington over Iraq has been questioned.

Presence on the United Nations Security Council
As Michael Portillo eloquently argued, if being a nuclear power means that you can sit on the Security Council, then the nations of the world should be inviting India, Pakistan and Israel to join and should be preparing to welcome North Korea and Iran.[41]

Status within Europe
A former defence chief is quoted as saying that no Prime Minister would contemplate the situation where France was the only West European nuclear power.[42] Michael Portillo has ridiculed the suggestion that this was a serious consideration.

Employment
In a debate on Trident in the Scottish Parliament one of the arguments used for retaining nuclear weapons was concern about jobs at the Faslane naval base. The nuclear weapons programme is a very inefficient job creation project. The same amount of Government funds would create more jobs in the UK if used for almost any other purpose.

Preventing war

Michael Quinlan has spoken of "the current nuclear-based system of war prevention".[43] He described nuclear weapons are "the keystone of the arch of freedom from war". He argues that the penalty from conflict is higher when nuclear weapons are part of the equation and so war is less likely. He described a country with nuclear arms as a nation which no-one can afford to make desperate. Nuclear weapons are described as the ultimate guarantee of Britain's security. Tim Hare, while rejecting the idea of warfighting, argues that nuclear weapons "have a political function in preventing war between nation states."[44]

The victims of war since 1945 are witnesses to the weakness of this argument. In the last 60 years over 25 million people have died in conflicts. For all but 26 days there has been a war raging in some part of the globe.[45] The possession of nuclear weapons contributed to the hostility between East and West that fermented conflict around the globe during the Cold War.

It is claimed that NATO had nuclear weapons and the Warsaw Pact never invaded Western Europe, so nuclear deterrence works. But the logical connection between the two points is not intrinsic and is questionable. It is likely that there was no clear intention to attack and there were other reasons for restraint.

Where coercion is used to influence another government to follow a course of action, it is difficult to be certain if it has worked. Where the object is to deter the opponent, so that he does not follow a particular course, it is even harder to assess if the policy has been effective. One US military study notes – "rarely does the evidence exist of the deterrent threat clearly dissuading an aggressive actor".[46] Another says – "Empirical evidence for the effectiveness of deterrence is limited and ambiguous".[47]

Central to the theory of nuclear deterrence is the ability to correctly anticipate how the opponent will respond when threatened. Yet deterrence is likely to be applied against a country which holds different values and whose response is most difficult to predict. Lee Butler says that deterrence requires – "a near perfect understanding of an enemy from whom we were deeply alienated and largely isolated".[48] In the build up to confrontation there is always a deliberate campaign to stereotype and caricature the enemy. The accurate judgements which deterrence demands are impossible.

While the US developed complex models of deterrence, the Soviet Union saw a potential danger of nuclear war and prepared to fight it as best they could. The two sides did not share the same outlook. Western understanding of the personalities, processes and policies of Soviet nuclear decision-making was limited. The situation with China is worse. There is concern amongst US advisers that China is less likely to play by America's rules of the game of deterrence.[49] With regard to "rogue states" and terrorists the problems magnify. There is widespread concern that the leaders of "rogue states" and terrorists will fail to respond in the "rational" way, which US planners would expect. One recent US report suggests that the greatest danger is not from these "rogues" but from an "unglued" major nuclear power, a nation with many nuclear weapons that is disintegrating, and in the hands of an erratic leadership. Again it is anticipated that, in this situation, models of deterrence behaviour would fail completely.

If nuclear weapons prevent major war, then they should reduce the risk of conflict wherever there is hostility. India and Pakistan's nuclear status should be praised by the international community rather than condemned. Israel's bomb should be welcomed as a focus of stability in the Middle East. North Korea and Iran could make a strong case for gaining nuclear status. Why limit the value of the bomb to recognised sovereign states? Surely Chechnya should have its own nuclear weapons to prevent conflict with Russia. And, reducio ad adsurdum, if Al Quaeda had the bomb, then the violence of the war on terror would be reduced.

Promoting nuclear weapons as instruments of war-prevention and at the same time condemning proliferation is linked to maintaining a two-tier system. On the one hand there are responsible states, the initial five nuclear powers; and on the other there is everyone else. This arrangement has been rightly criticised. In any case it is not correct to assume that the five share the war-prevention approach. Our main nuclear partner and ally, the United States makes provision to use its nuclear weapons for warfighting. The idea that British nuclear weapons are different and serve a benevolent peaceful function is a myth.

If the utility of British nuclear weapons stems from their ability to prevent war, then what war are they likely to prevent? There is no obvious realistic scenario.

Insurance against uncertainty

According to Quinlan, since the end of the Cold War the case for Britain's independent nuclear capability rests on "the sense of a very general insurance against the future's long-term uncertainties".[50] Paul Robinson, a key figure in US nuclear policy, has spoken of the need for two capabilities - one to deal with Russia and the other for wider threats.[51] The second he called the "to whom it may concern" force. Quinlan has echoed this idea and speaks about "the very general 'to whom it may concern' character of UK nuclear deterrence".[52] Michael Clarke refers to the existential nature of British nuclear deterrence – based on possession of the bomb rather than on preparation to use it against a specific opponent. Deterrence of some threat that the future may hold has also been called virtual deterrence.[53]

Any country in the world could argue that they should have nuclear weapons because of long-term uncertainties, Britain is not unique in being unable to accurately predict the future, and many will feel they could make a stronger case. There is no immediate threat to British security from any other country. In contrast many nations perceive threats from their neighbours. If it is right for Britain to have the bomb then they can argue they have a stronger case to seek or retain nuclear status.

While it may not be Quinlan's intention, to the public "future long-term uncertainties" will bring to mind the potential for major terrorist attacks. While this is not a significant feature of British nuclear policy, language is used that suggests it is.

Britain must have nuclear weapons so long as any other country does

The Conservative Defence Spokesperson, Julian Lewis, argued that Britain should retain nuclear weapons so long as other countries have them.[54] It is argued that the nuclear genie is out of the bottle and can't be put back in, so Britain must keep the bomb. Jonathan Schell summarised the views of those who advocate this approach - " In the land of the disarmed … the possessor of one nuclear bomb is king".[55] Schell also quotes Robert O'Neill's response to this argument. If there was only one country with nuclear weapons, and if that one country used them, it would face "unimaginable retaliation by the whole international community, backed by intense public outrage around the world."[56]

It is wrong to say the only factor that dissuades countries from using nuclear weapons is that other nations possess them. In 1966 a group of Pentagon advisers studied the utility of tactical nuclear weapons in the Vietnam conflict.[57] They concluded that there was no useful role they could play. This was partly due to the lack of suitable targets, but it was also because abstaining from using nuclear weapons was a "universally recognized as a political and psychological threshold".[58] Crossing the threshold would not be in the interest of the US. A nuclear attack would be condemned around the world, including by America's allies. Regardless of how much work was done to prepare the public at home it would be politically divisive. In the first Gulf War the US considered whether or not to use nuclear weapons in extreme circumstances. The option was ruled out for similar reasons to those described in the Vietnam study. The government would pay a heavy penalty in the loss of good will and support around the world and from public outrage at home.

The desire to develop lower-yield nuclear weapons illustrates the importance of the nuclear taboo. The destruction from a large nuclear weapon would be so extensive that there would be international condemnation if one were used. For this reason some US nuclear policy makers advocate building smaller bombs. However their plans are flawed because, while fallout would be less, it would still be universally unacceptable.

The nuclear taboo offers an alternative way of dealing with the most worrying uncertainty - that Britain could possibly face coercion from a nuclear-armed opponent. It is a mistake to assume that it is only nuclear arms and nuclear alliances that prevent nuclear coercion. The main restraint is consideration of the international response to any nation that crossed the nuclear threshold.

The main way to deal with the threat of nuclear weapons is to increase the sense in which it is totally unacceptable for them to be used. As part of this there is a need to make the possession of nuclear weapons unacceptable – "it should become a commonly held belief that it is dysfunctional for any one nation to have them".[59] The forthcoming review of British nuclear policy will have an impact. If Britain retains nuclear weapons, particularly on a flimsy basis, the nuclear taboo would be weakened. If Trident were not replaced then the taboo would be strengthened.

Disarmament would be irreversible

In the absence of a credible current or future threat, one argument used to justify keeping nuclear weapons is that once given up they would be very hard to restore. Tim Hare argues - "any decision to do away with our nuclear capability would be irrevocable".[60] He considers that the cost of restoring a nuclear-weapons' infrastructure would be "astronomical". The lost of expertise would be a particular problem. An additional factor, which is not mentioned, is loss of US support. The possibility that America would not resurrect the special nuclear relationship may be a significant factor underlying the desire to retain the bomb.

If nuclear weapons are retained indefinitely it is inevitable that they will be used. The Non Proliferation Treaty requires Britain to make progress towards disarmament. The Labour government say they are committed to moving towards disarmament. So the question is not if Britain will cease to become a nuclear-weapon state but when. Against this background it is hard to sustain the argument that we should keep nuclear weapons because once lost they could not be regained.

Comment

A former Defence Minister, Michael Portillo, and a former Foreign Minister, Robin Cook, have both argued strongly in public that there is no reason to replace Trident.[61] A number of different rationales are presented for retaining British nuclear weapons. There is vague allusion to a number of arguments. The impression may be left that somewhere there is a genuine case for keeping the bomb. But if looked at individually, these arguments do not stand up to close scrutiny. None of them effectively counterbalance the substantial costs and risks of continuing nuclear status.

The costs and risks of keeping the bomb

Retaining nuclear weapons comes with a substantial price tag, not just in financial terms but also in the risks they bring and the effect they have on other nations. Not replacing Trident would bring positive benefits.

Proliferation

The proliferation of WMD is a serious issue. Britain's nuclear weapons, far from contributing to tackling this problem are making it worse. It is said that other nations, when weighing up the case for having nuclear weapons, will take no account of what Britain does. They will make a judgement based on their own perceived needs and costs. But this is not the case. Just as Britain uses other nations' possession of the bomb to justify our programme, so they can be expected to do the same. If having nuclear weapons allows Britain to retain the status of a Great Power, so other governments can argue that their international status and influence will be enhanced by a nuclear capability. India's leaders can argue that they are no longer eunuch's because they have the bomb.[62] Japan could develop nuclear weapons as a symbol of independence from America. Bruce Blair has explained that, "others have been listening and they have been learning the lesson's we've been teaching."[63]

The way to deal with nuclear proliferation is through diplomacy. In these negotiations Britain's possession of nuclear arms is a factor. The 2005 review conference for the Non Proliferation Treaty was hampered by the divergent approaches taken by delegates. Nuclear Weapon States and their allies argued that the conference should only consider the new risks from countries such as North Korea and Iran. Many non-nuclear countries insisted that the five longstanding nuclear states should also make progress towards disarmament. The failure to agree the agenda impeded the conference. British calls for restraint are easily condemned as hollow, when the justification for our own arsenal rests on such a flimsy foundation and uses arguments that any country could adopt. As Lee Butler has said, "… it is untenable that a handful of nations should forever arrogate to themselves the right to nuclear weapons, while denying it to others."[64]

If Trident were not replaced then Britain would be making a positive contribution to tackling proliferation. We would be saying to other states that nuclear weapons are not a suitable response to specific or general concerns.

In his 1993 speech on nuclear weapons Malcolm Rifkind recognised that the development of lower-yield nuclear weapons could undermine moves to tackle proliferation. There may be some acknowledgement, within the British nuclear establishment, that promoting nuclear warfighting can encourage proliferation. There is a failure to recognise that maintaining a nuclear arsenal on the basis of abstract concepts of deterrence can also contribute to more nations acquiring the bomb.

Relationship to other nuclear arsenals

The relationship between existing nuclear states is complex. US nuclear plans are still primarily focused on Russia, but there is growing emphasis on China. The new US policy of Global Strike means that weapons will be poised to attack any target in the world. Israel's bomb could be a catalyst, drawing the US into a nuclear conflict in the Middle East. American planners are concerned that regime change in Pakistan could place their nuclear weapons in the wrong hands. India is concerned not just with Pakistan, but also with China.

The British bomb does not exist in isolation from the arsenals of other nuclear powers. For example, the US is concerned about "rogue states" acquiring WMD and so plans Missile Defences. China could respond by building MIRV'd missiles. These missiles would also be a threat to Russia. This could spur Russia to improve its ABM defences, which could in turn lead to Britain building more nuclear weapons.

International law

The continued possession of nuclear weapons undermines Britain's desire to promote international law as the basis for orderly relations between states. The Basic Rule of the Geneva Convention (1949) says that combatants must protect the civilian population by distinguishing between civilian objects and military objectives, and only attacking military objectives.[65] British nuclear policy has not been consistent with this. The early Anglo-American plans and the later NATO battle plans allocated most British nuclear weapons to military targets. However independent British plans, for the V bombers and for Polaris, targeted Soviet cities. In a study of this issue Michael Quinlan wrote, "For UK staffs, national plans that tasked Polaris in the countercity role were the prime focus of attention".[66] Implementing these countercity plans would have been contrary to the Geneva Convention.

British planners were aware of the ethical problems of targeting civilian populations. Trident offered greater accuracy than Polaris and independently targeted warheads. It could be used against a wider range of targets, such as key command bunkers. When Trident was ordered, in 1980, the Ministry of Defence said: "[the Government's] concept of deterrence is concerned essentially with posing a potential threat to key aspects of Soviet state power".[67] Michael Quinlan explained that this phrase "was intended to imply targeting concepts which, while still countervalue and not promising to exempt cities or in particular Moscow, would not be exclusively or primarily directed at the destruction of cities".[68]

Two alternative terms used in nuclear strategy are countervalue and counterforce. A counterforce attack is essentially a strike against the opponent's nuclear forces, to eliminate them or limit the damage they could cause. Countervalue attacks focus on targets of value to the opponent, which can include cities. British nuclear forces, on their own, could not significantly reduce the damage that Russian missiles could inflict. So British plans for an independent attack on Russia are essentially countervalue. The legal advisers to STRATCOM have suggested that the events of 11th September 2001 could be described as a countervalue attack. They now avoid using this term.

The yield of the warheads on British Trident submarines is around 100 kilotons. The airburst detonation of a 100-kiloton warhead would be expected to kill almost all civilians within 1.6 kilometres of ground zero and 55% of those between 1.6 and 2.9 kilometres of ground zero.[69] Any use of this weapon would result in a large number of civilian casualties.

In 1996 the International Court of Justice ruled that "the threat or use of nuclear weapons would generally be contrary to the rules of international law applicable in armed conflict and in particular the principles and rules of humanitarian law."[70] This is significant for the decision on the future of British nuclear weapons in two ways. Firstly in order to promote international law, including the laws of war, the Government must try to observe the law itself. Not replacing Trident would signal that Britain is serious about international law. Pursuing a replacement would indicate that we wish to pick and chose which laws to follow and that Basic Rule of the Geneva Convention is outside our selection.

Secondly, international law has a bearing on the role of British nuclear weapons. One sentence in the ICJ verdict has been regarded as a potential loophole. The judges said, "the Court cannot conclude definitively whether the threat or use of nuclear weapons would be lawful or unlawful in an extreme circumstance of self-defence, in which the very survival of the State would be at stake." They did not rule that in this situation nuclear use would be lawful. The President of the Court made it clear that the failure to go further "cannot in any way be interpreted as a half-open door to recognition of the legality of the threat or use of nuclear armaments".[71]

British policy could be constructed so that nuclear weapons could only be used in the situation described, where the survival of the State was at stake. This would be a far narrower role than that claimed in the various rationales presented for retaining nuclear weapons. The ICJ recognised that not only "use" but also "threat to use" would be illegal. Advocating that nuclear weapons could be used as a deterrent to defend vital interests, to prevent war or to counter proliferation would all go beyond the narrow area about which the ICJ was unclear.

The price of failure

The theory that nuclear weapons prevent war, is not only empirically unproven, but rests on the assumption that it is possible to sustain a nuclear threat with little prospect of the weapons actually being used. Nuclear possession cannot be justified on the basis of "the future's long-term uncertainties" because of its costs and risks.

The practice of nuclear deterrence during the Cold War was highly dangerous.[72] Lee Butler's assessment is that it was only by divine providence that use of nuclear weapons was avoided. He also said – "the risks and consequences of nuclear war have never been properly understood by those who brandished it".[73]

Operationalization

Lee Butler has shown that there is a gulf between abstract theories of deterrence and their implementation in practice.[74] Operational requirements take on a life of their own. Nuclear planning in the US and Russia is dominated by the vulnerability of command and control systems. The emphasis is on rapidly launching a large part of the nuclear force at an early point in a nuclear exchange. The theory may be that the US retains the ability to strike back if it is subject to a nuclear attack. The practice is that hundreds of missiles are poised ready to fire in the short period, less than half an hour, between when a Russian missile is launched from its silo and when it reaches its target in America. Although a US attack must be authorised by the President, he or she would be given very one-sided advice and would only have 3 minutes to decide. It is almost inconceivable that, in this situation, an attack would not be authorised.

The fathers of nuclear deterrence argued that possession of the bomb was not enough. It was essential that all the components were in place ready to launch an attack. There had to be prepared hardware, trained personnel, detailed plans and a conspicuous readiness to act. Today Britain has a system for creating nuclear attack plans and a submarine on patrol ready to implement such plans. The notion that the political and military aspects of nuclear deterrence can be separated is false. This myth can contribute to underestimating the risks of nuclear weapons being used deliberately, by accident, or as a result of misunderstanding.

Miscalculation

During the Cuban Missile Crisis the White House tried their best to manage events in a rational way. Former US Defense Secretary Robert McNamara has revealed that dangerous mistakes were made because of poor intelligence and miscalculation. Assessments of how Russia might react were inaccurate. Intelligence agencies had not realised that tactical nuclear weapons were already deployed in Cuba and that authority to use them had been delegated to Russian commanders on the ground. The US had underestimated the risk that an invasion of Cuba would have triggered nuclear war. McNamara concluded: “I believe that was the best-managed Cold War crisis of any, but we came within a hairbreadth of nuclear war without realising it”.[75] He is concerned that in future a country could find itself manoeuvred into a situation where nuclear weapons would be used, even though this would not be rational. He argues that the fog of war and human fallibility make the use of nuclear weapons inevitable if they are retained indefinitely.

Britain’s involvement in the invasion of Iraq was founded on the mistaken belief that Saddam Hussein had not destroyed all his chemical and biological weapons after the first Gulf War. It was wrongly assumed that he had continued to stockpile Weapons of Mass Destruction. A nuclear strike based on poor intelligence would be particularly catastrophic.

The theory that nuclear weapons contribute to peace is based on a false perception of the extent to which decisions in international relations are calm, rational, predictable well-informed and cautious. In contrast US nuclear policy makers have recently argued that they should project their nation as irrational and vindictive.[76]

The effects of nuclear use

A single Trident warhead used against a military installation, such as a naval base in Northern Russia, could cause around 23,000 civilian fatalities. If the target was inside a city then there could be 150,000 – 200,000 deaths. If the warheads from one British submarine were exploded at military targets in the Moscow area, most of them outside the city, this could result in around 3 million deaths. This figure would rise to between 9 and 30 million if the warheads on all three armed submarines were detonated.[77] These figures only include short-term fatalities. The long-term effects of radiation, environmental damage and the destruction of infrastructure would substantially increase the death rate. Studies have shown that a US counterforce attack on strategic military targets in Russia would result in massive civilian casualties.[78] The raw figures do not give a true picture of the horror that would be inflicted on individual women, men and children. The photographs and accounts from Hiroshima and Nagasaki provide a glimpse of the monstrosity of nuclear weapons.

Accident

A US study distinguishes three types of nuclear accident scenario.[79] The first situation is an unauthorised launch of a weapon by a rogue commander or a terrorist. The second is where a launch takes places by mistake, as a result of a training accident or a system malfunction. The third scenario is where incorrect information results in an intentional launch.

A number of situations fall into this third category. There could be an error or malfunction in the early-warning systems which are designed to detect a missile attack. A non-threatening event could be misinterpreted. There could be a false perception that another country had launched a nuclear attack, or a misperception that a nuclear weapon had detonated within the homeland. Lastly, a training attack could be misinterpreted as a real attack.

The report touches on the connections between the possession of nuclear weapons, relations between Russia and the US, and the risk of accidental use. It suggests that de-alerting moves could improve relations between the two countries and so provide a basis for more substantial measures. It recommends that several immediate unilateral measures be taken within 6 to 12 months. One proposal is to move Trident submarines further from Russia. Britain’s Trident force is not mentioned, but for geographical reasons it could be seen as a particular threat because of the proximity of patrol areas to Russia.

The analysis concludes, “The risk of accidental or unauthorised nuclear use is too high given the markedly improved relationship between the

United States and Russia. This is in part because nuclear weapons now play a role out of proportion to other aspects of the relationship".[80] Adherence to nuclear deterrence is an obstacle to progress towards lowering risks and improving relations – "A central reason for the phased approach is that some options for improving safety would push too far beyond current deterrence practices and orthodoxies to be acceptable".[81]

The risk of a nuclear weapons accident has been considered particularly in the context of the large American and Russian arsenals on a high state of alert. But the dangers also apply to other nuclear powers. For Britain's part there is a need to recognise that our nuclear weapons contribute to the risk of an accident. Also each step that we take towards disarmament will contribute to building a better relationship with Russia. What is blocking progress is continued adherence to outdated and dangerous theories about nuclear deterrence.

Financial costs

Cost will be a major factor determining the future of British nuclear weapons. Michael Quinlan concedes that if today he had to decide whether or not to embark on the Trident programme then the cost would not be justified. Admiral Sir Raymond Lygo suggested that the cost of Trident should be capped at a level relative to the threat from Russia and China.[82]

A complete rebuild of a Trident-like system would cost over £15 billion. If the submarines are replaced each one would come with a price tag of more than £1 billion. A substantial warhead upgrade would be very expensive and building a new weapon would cost more again. A significant proportion of any new expenditure would go to American contractors.

The official estimate of the annual cost of the nuclear weapons programme is between 2 and 3 per cent of the defence budget. This is equivalent to between £700 million and £1 billion each year. Taken over the 30-year life of a system this adds up to between £21 billion and £30 billion, more than the capital cost.

The substantial overheads of the nuclear-powered submarine programme are partly due to Trident and partly to the conventionally-armed force. The primary mission of the latter is the protection of Trident. There are huge potential savings to be made by giving up nuclear-powered submarines. Estimates of the cost of decommissioning defence nuclear facilities have increased several times in recent years. The long term costs of storing nuclear waste will increase with each year Britain continues to have nuclear weapons and nuclear-powered submarines.

In assessing the cost of upgrading Trident, or acquiring a replacement, the budget should include not only capital costs but also the total revenue cost throughout the planned life of the system, including decommissioning.

Aspects of British nuclear policy

Uncertainty

British military planners have never adopted the doctrine of a nuclear trip-wire. They have never clearly spelt out that a particular action would be certain to result in a specific nuclear response. They have made a virtue of ambiguity, even if the source of that ambiguity was the lack of a clearly thought out and agreed policy.[83] This approach was restated by Kevin Tebbit of the MoD in 2000, "The fundamental principle of nuclear deterrence is uncertainty".[84] With regard to Sub-Strategic Trident he said "it does not help to say precisely the circumstances in which we might use Trident in a sub-strategic way, it is sufficient for the potential aggressor to know that if it were used it would outweigh any benefit he might wish to gain".

In January 2003 a Parliamentary Committee asked Tony Blair if he would warn Saddam Hussein that Britain could use nuclear weapons. He replied: "It is best to say that we are aware of the potential of the threat and we would deal with it in any way that we thought necessary. But I don't think it is wise for me to get into speculating as to exactly what we are doing about it."[85]

The US has a policy of "studied ambiguity" with regard to the role of nuclear weapons against wider threats, "We must be ambiguous about details of our response (or pre-emption) if what we value is threatened, but it must be clear that our actions would have terrible consequences."[86] Kevin Tebbit's comments and the Prime Minister's statement indicate that studied ambiguity is probably at the heart of British policy. Clearer threats, such as Geoff Hoon's replies to questions on Iraq, should be seen in this context.

Ambiguity and bluff have been at the heart of nuclear weapons policy for decades. A central tenet of NATO strategy was that if Soviet troops crossed into West Germany the United States would use nuclear weapons on the battlefield, which could result in a nuclear exchange between Russia and the American homeland. But yet to implement this policy would not have been rational. It was not a certainty that this is what would happen; it was a possibility that it might. Robert McNamara advised two Presidents that they should say clearly to Russia that they would carry out this policy, but if they were ever faced with the real situation, they should not implement it.[87] Mikhail Gorbachev said, "NATO's strategy of initiating local nuclear war was, I think, bluffing".[88]

In the First Gulf War there were hints that if Saddam used Chemical weapons then America would make a nuclear response. Assessments were carried out of potential targets. But behind the scenes the decision was made that in no circumstances would nuclear weapons be used. When NATO became involved in Kosovo, President Yeltsin engaged in some nuclear sabre-rattling. This was interpreted by the West as a hollow threat and ignored.

Prior to the invasion of Iraq the West believed Saddam Hussein still had chemical weapons, because of the ambiguity he had created over this issue. As Hans Blix said, you can put a sign on your gate saying, "beware the dog", but it does not mean that you have a dog. Britain's weapons are real, but successive Governments have concealed the extent of dependence on the US and made vague threats that are not credible. The promotion of ambiguity echoes the policy of Iraq's former leader.

It may be reassuring that many threats to use nuclear weapons have included a substantial element of bluff. But the dishonesty of nuclear policy may inflict a heavy price. In the climate of uncertainty crisis management becomes, not a careful rational process, but a poker game in which the players try to guess what the opponent intends to do, despite the signals he is sending. And the stakes are very high. The bluff may be called. The leader who has made a hollow threat may have to choose between humiliation and the irrational use of nuclear weapons.

Minimum deterrence

In considering the future of British nuclear weapons it is likely that the question of what is a minimum deterrent will be addressed. In 1961 a study was carried out to determine how many Soviet cities the British nuclear force should be able to destroy. Was it necessary to target 40 cities, would 10 be enough, or 5 ? The conclusion was that 15 or 16 would be adequate.[89] The issue was not decided purely on calculations of what the Soviet leadership would regard as unacceptable damage. Lord Home, then Foreign Secretary, said that the capability of British nuclear forces should be determined on the basis of "what the Americans will think".[90] The force was to be sufficiently destructive to persuade Washington that Britain was making a substantial contribution to Western defence.

The 1961 recommendation pre-dated the Polaris Sales Agreement. However, the number of targets specified, 16, was the same as the number that could be destroyed by one Polaris submarine. Chevaline replaced the initial Polaris system and was designed to attack targets in Moscow, around which the Soviet Union had constructed an Anti Ballistic Missile (ABM) defence system. The submarine on patrol with Chevaline warheads still had the capability to attack 16 targets.

The upgrade from Chevaline to Trident substantially increased the number of targets that could be destroyed. The size of the Trident force was determined by projections of how it would be used against targets in Russia, particularly taking account of the Moscow ABM system. Several months before the first Trident submarine was deployed, the MoD had still not determined how many warheads it would carry.

Until July 1998 British Trident submarines were each armed with 60 warheads.[91] One submarine could attack 60 separate targets, compared with the 16 sites that Polaris and Chevaline could destroy.[92] The Strategic Defence Review reduced the number of warheads on each submarine to 48. The 36 warheads that were removed were not dismantled but have been retained to "provide the potential to deploy additional weapons should that ever become necessary".[93] The number of warheads currently deployed is the same as that initially on the Polaris system. This may have been a significant factor in determining how far to scale down the force.

British strategic nuclear forces were and are sized for an attack on Russia. In the 1950s and 1960s the calculations were carried out in a rather haphazard way. A major factor was how Washington would assess the British capability. With Trident again there appears to have been considerable uncertainty within the MoD over how many warheads were required. In addition to the submarine on patrol, there have been 2 other fully armed submarines that could go to sea, given sufficient notice.[94]

Britain's battlefield nuclear forces have been dismantled and the sub-strategic force is smaller. At the same time the strategic force is substantially more powerful today than it was in the 1980s. Trident is far more accurate and can attack three times more targets.

Michael Clarke argues that the current force is a minimum because the number of British nuclear weapons has declined and we have fewer than the US, Russia, China, France and Israel. He also asserts that this force is "incapable of an effective first strike".[95] Yet if the purpose were to threaten a nuclear strike on North Korea or Iran then a force of 144 nuclear warheads, 48 of them deployed on patrol, does not appear to be a minimum. Nor is it incapable of a first strike against all opponents.

Invulnerability

Consideration of the principle of invulnerability is likely to play a significant part in the review of nuclear policy. Arguments will be presented showing the financial or practical advantages of moving to an aircraft-based system. Navy advocates will counter that only a submarine-based system is invulnerable.

A key part of current nuclear policy is that one armed Trident submarine is kept on patrol at all times. The Strategic Defence Review (1998) reduced the state of alert, but maintained the practice of continuous patrols. Proposals to reduce the state of alert further, by taking Trident off patrol and separating its components, were made during the Strategic Defence Review. These suggestions were dismissed in the final report.

It is argued that it is more stable to have a submarine on patrol. If all the submarines were in port then it would be possible for them all to be destroyed in the early part of a nuclear exchange. If there were no invulnerable submarine at sea, then there would be a greater call to fire the missiles from the submarines in port during a crisis, before they were destroyed. However the real progress in de-alerting would be to separate the components. Taking the submarine off patrol is a step towards this. It would be a mistake if the ongoing risk were sustained because of the failure to accept whatever short-term risks there might be in having armed submarines in port before the missiles and/or warheads were removed.

It is also said that if the missiles and/or warheads were removed then there could be a race to reassemble them in a crisis. However force generation can either build up tension, or it can encourage the opponent to reconsider and step back from the brink. The US regards modifying the armament of nuclear forces, deploying submarines and raising alert states as Flexible Deterrence Options. They are measures that can be taken to help to prevent hostile action.[96]

The crucial issue behind keeping Trident fully assembled and on patrol is the perceived need for invulnerability. On one side of the coin of invulnerability is the confidence that part of Britain's nuclear force will survive any attack. The other side of the coin is that this force can launch a devastating nuclear strike at any time. As a basis for the relationship between the US and Russia this mutual suicide pact was always highly dangerous. Extending this principle to three, five, eight or many nuclear powers is a recipe for disaster.

The invulnerable nuclear force is by its nature a threat to others. Trident as deployed today signals to Russia that conflict is considered a serious possibility and that if it occurs Britain is prepared to launch a devastating nuclear attack. Alongside the message that the deployment of Trident sends, statements indicating that Russia is no longer an enemy are hollow. For all the fears of vulnerability and a potential race to reassemble a dismantled system, tying submarines up in port and removing their nuclear weapons send a clear signal that you don't intend to use them.

Pre-strategic weapons

One strand in British nuclear planning is that nuclear weapons can be used to give a warning. In 1963 a report said, "The use of a very small number of low yield weapons would convey a powerful warning of allied determination".[97] The document noted that while this might encourage the Soviets to stop an attack, it could have the opposite effect and trigger a strategic nuclear strike from Russia.

A review of British and US views of tactical nuclear weapons in the same year gives two circumstances in which Britain might use these forces. One is a substantial attack to force the Soviet Union to either withdraw or escalate to a strategic nuclear war. The other is the use of tactical nuclear weapons "in small numbers as a warning".[98] Both British and American contributors to the discussion agreed that, in this latter case, an attack would gain no significant military advantage and that it was unclear if there would be any political gain.

The notion of a warning shot survived into the 1970s and 1980s. Field Marshall Lord Carver had a low opinion of this policy – ".. when I was chief of defence staff, there was this absurd idea – I was laughing about it with Lord Carrington, the foreign secretary – that you would fire one off into the Pripet Marshes, or somewhere, and say 'That's to show you that I would be prepared to use nuclear weapons.' Now what happens ? He fires one back, and it lands in a bog in Scotland. He says, 'That's just to show you'".[99]

In 1991 Michael Quinlan, Permanent Under Secretary of State at the MoD, said that non-strategic nuclear weapons could be used to communicate to an opponent - "you have wholly underestimated my determination to defend my interests; for your own survival, you must now stop". The warning is that the next step would be a strategic nuclear attack.

Quinlan's statement is of assistance when it comes to interpreting what Malcolm Rifkind said in his speech two years later. Mr Rifkind said that in some circumstances an aggressor might feel that Britain would not be prepared to launch a massive strategic nuclear attack. In these circumstances Britain needed Sub-Strategic Trident to "deliver an unmistakable message or our willingness to defend our vital interests to the utmost".[100] The message is that Britain is prepared to launch a strategic nuclear attack. French tactical nuclear weapons have been called "prëstrategic", because they too could be used to give a warning.[101] Britain uses the term "Sub-Strategic", in line with the current NATO designation, however the term "pre-strategic" is more appropriate for this warning-shot approach.

In the Cold War NATO developed the policy that sub-strategic nuclear weapons were the bridge between conventional forces and strategic nuclear arms. Although the scenario around which this was created, a Soviet invasion of Western Europe, is not longer possible, the policy has survived.

Malcolm Rifkind says, in the introduction to his speech, that his statement about vital interests refers to action taken in support of NATO.[102] When junior Defence Minister, John Reid used almost identical words to Rifkind, saying clearly that this applied to action under NATO auspices. This suggests the phrase "deliver an unmistakable message or our willingness to defend our vital interests to the utmost" should be interpreted in the context of the traditional Alliance view that sub-strategic nuclear weapons act as a link between conventional forces and strategic nuclear forces.

Echoing Quinlan's emphasis on determination, the Defence Minister Lord Gilbert said in 1999 that "a more limited use of nuclear weapons would allow us to signal to an aggressor that he has miscalculated our resolve, without using the full destructive power that Trident offers."[103]

In 2003 an MoD briefing on Trident described the Sub-Strategic role as: "the credible ability to threaten nuclear action on a carefully limited scale, manifestly short of the ultimate sanction of strategic nuclear action it provides the linkage between strategic and conventional deterrence."[104] If the last phrase were omitted then this could refer to any nuclear attack on a smaller scale. However, again, it is tied to the anachronistic NATO idea that the Sub-Strategic forces are the bridge between conventional arms and strategic nuclear forces.

Divergence and Dependence

It is scarcely credible that Britain could use nuclear weapons in a situation where the US opposed their use. It is far more likely that they would be used as a component of a US nuclear plan. But there appear to be differences in the approaches to nuclear policy on either side of the Atlantic. The emphasis in Britain is on the political role of the bomb, particularly preventing war. For US policy-makers deterrence is only part of the picture. There is no hesitation in acknowledging that deterrence requires preparation for war. In some situations deterrence may not be appropriate and action, including pre-emptive action, could be required. Michael Quinlan focused on the uniqueness of nuclear arms, while US planners consider developing more useable nuclear weapons.

It has been argued that Britain can exert a moderating influence on American policy.[105] But our ability to change US doctrine is very limited. We have inherited a situation where our nuclear forces are tied to an American system. That system is now moving in a direction which is at odds, not only with wider public opinion, but probably also with the thinking of the British nuclear establishment.

Nuclear Options

This section looks at some of the alternative nuclear systems that may be considered in a review.

More of the Same

Tim Hare has argued - "more of the same remains the only sensible option".[106] Extending a system based on Trident missiles for as long as possible is probably at the forefront of minds within Whitehall. This reflects current American plans.

US plans for Trident

The D5 life extension (LE) programme is designed to extend the life of the missile system by 15 years and to keep Trident in service until 2042, when the newest submarine, USS Louisiana, is due to retire. An additional 115 missiles are to be built between 2008 and 2013.[107] A Next Generation Guidance system is being designed to support D5 LE.[108]

On a longer timeframe, the US Navy has begun studies to examine range, payload and size specifications for a replacement Submarine Launched Ballistic Missile (SLBM). The new missile would be required in 2029 when the oldest Trident submarine, USS Henry M Jackson, is due to be decommissioned. There are a number of research projects looking at basic technologies for future SLBMs and land-based Inter Continental Ballistic Missiles (ICBMs). A common design for SLBM and ICBM is one option.

The plan to keep Trident in service until 2042 is based on projections of the hull and reactor life of Ohio class submarines. HMS Ohio completed 22 years on its first fuel core. The US Navy plans to repeat this with each submarine and for them each to serve a further 22 years after a mid-life refuelling. On this basis they have extended the planned life of Trident submarines from 30 years to 45 years.[109] The US Navy have also commissioned initial studies for a next generation ballistic missile submarine, which would enter service in 2029. They are considering whether this should be based on the Virginia class or a new design.[110]

The largest element of the US nuclear weapons programme is the project to extend the life of the W76 warhead to match the new 45-year timeframe of Trident submarines and missiles. The plan is to produce the first batch of upgraded warheads (W76-1) between 2008 and 2013. These will have a planned life of 30 years. While these are being modified, a decision will be made whether to upgrade more warheads, or move to another design. The initial focus of the Reliable Replacement Warhead programme, initiated in 2004, will be on Trident warheads.

Extending the life of Britain's Trident system

Britain leases Trident missiles from the US. In February 2002 the Government said they had no plans to purchase the new upgraded missiles. The life of the British Trident system could only be extended if the US agreed to supply these missiles over the additional period for a negotiated price.

It is unlikely that the Royal Navy can reliably predict that Vanguard class submarines will have a life equal to that the US Ohio class. The official hull life of the Vanguard class remains 25 years. On this basis the first submarine would retire in 2019 and the last in 2024.

Rolls Royce and Associates have developed a new fuel core for British submarines. Core H is being installed on Trident submarines during their refit and on the new Astute class. It is designed to last the life of the Astute class, 25 years.[111] This suggests that the life of Vanguard class submarines could be extended. However the fuel core is not the only factor that determines reactor life. The safety and reliability of the reactor itself are also crucial. There have been a series of defects on British submarine reactors in recent years. As they grow older the Vanguard class may be hit by similar problems. The predicted life of Trident reactors will be adjusted on the basis of information from the prototype reactor at Dounreay, from inspections during submarine refits and from HMS Vanguard's second visit to Devonport, scheduled for 2012. The life of the submarine hull is also critical. The depth to which a submarine can dive may be reduced as the vessel ages. Hull and reactor problems dogged British Polaris submarines in their final years.

In June 2004 Geoff Hoon disclosed that concept studies had been carried out on "options for platforms to carry the Trident missile in the longer term".[112] One option would be to extend the life of existing submarines. Another would be to build new vessels. If the US retains Trident until 2042, replacement British submarines could be in service for 20 years. These replacements could either be identical to existing submarines or could be a new design. The Royal Navy is investigating one common design for future ballistic missile and conventional-armed submarines.[113]

A substantial commitment would be required to extend the life of the Anglo-American warheads on British Trident submarines. Most warheads were delivered to the Coulport armaments depot between 1993 and 1998. The frequency of warhead movements in by road in 2005 indicates that a refurbishment programme is underway. The plan may be to match the basic submarine life of 25 years by refurbishing the warhead once, after 12 years in service.[114] Any long-term plan would mean that the warheads would be replaced or refurbished again, starting around 2017.

The US is about to upgrade some of its Trident warheads to W76-1. Components of W76-1 could be used in a refurbishment of Britain's warheads in 12 years time. The W76-1 will have an improved fusing system. Upgrading British warheads to W76-1 would enhance the capability of Britain's Trident force. The US is also considering a more drastic re-design of the Trident warhead under the Reliable Replacement Warhead project.

Tim Hare suggests that Aldermaston may need to design a replacement warhead for Trident. This would have a similar capability and missile interface but would use modern technology and safety sub-systems.[115] This sounds like W76-1 or the Reliable Replacement Warhead. While the US might be willing to part with the key components and provide assistance, they would also expect Aldermaston to do some of the work themselves.

Britain is likely to be interested in US projects to make Trident more accurate and flexible, particularly if Trident is seen as having a long future. Research into manoeuvrable re-entry vehicles has stalled but this work might be resumed. If successful this would make Trident more accurate and could lead to the development of a lower-yield warhead. There are also proposals for a "go anywhere and shoot" capability. In years to come this could enable submarines to operate out-with areas mapped by the Ocean Survey Program.[116]

Nuclear Armed Sea Launched Cruise Missiles

The Tomahawk Land Attack Missile – Nuclear (TLAM-N) is a US sea-launched cruise missile. It was designed to attack targets too dangerous to strike with manned aircraft.[117] TLAM-N was first deployed in 1983 and the last of 367 missiles was produced in 1989. Ground Launched Cruise Missiles, deployed in Europe in the 1980s, were a version of TLAM-N.

Conventionally armed sea-launched cruise missiles were fired from submarines and surface ships in attacks on Iraq, Afghanistan, Bosnia and Sudan. The newer conventional missiles are more accurate than the nuclear version. Britain deploys conventional-armed cruise missiles on some submarines and plans to have this capability on all submarines.

In the 1970s the Foreign Secretary, David Owen proposed that Britain should purchase TLAM-N to replace Polaris. An MoD study concluded that, to match the devastating power of Trident, a large number of submarines armed with TLAM-N would have been required. This would have been more expensive than Trident. Recently deploying TLAM-N on Astute class submarines has been proposed as an option to replace Trident.[118] It is unlikely that matching the firepower of Trident would be seriously considered. A smaller nuclear capability may be proposed.

TLAM-N will only to be an option if it is available from the US. The signs are that the US Navy will scrap TLAM-N before the British Trident force reaches the end of its planned life. These cruise missiles are not a vital part of the US nuclear arsenal. They are Non-Strategic weapons. The missiles are assigned to theatre commanders, but none of these commanders has identified a role for them. No submarines are currently armed with TLAM-N.[119] Since 1992 the US has made an annual declaration to Russia stating that none of the missiles are deployed. Plans to extend the life of the W80 warhead are focused on the variant used on US Air Force Cruise missiles, rather than on the Navy version.[120]

Within the US Navy there is opposition to retaining TLAM-N. Attempts have been made to reduce funding for these weapons.[121] A US Defense Science Board study into future requirements concluded that there should be more emphasis on weapons customised for use against potential WDM targets. It advocated that the nuclear role for sea-launched cruise missiles should be eliminated because there was no military need for these weapons.[122] The Navy may begin to phase out them out shortly.[123]

The US is developing a more flexible form of Cruise Missile, tactical Tomahawk. This will be able to loiter over an area and be retargeted in flight. There are no signs of any plan to develop a nuclear version of this missile.

Superficially it might appear that TLAM-N would be suitable if Britain wanted to be able to join in a US limited nuclear attack. However these missiles are not a key part of the US arsenal and are less likely to be used than other American nuclear weapons.

Submarine Launched Intermediate Range Ballistic Missiles

In 2003 the US initiated basic studies into the feasibility of developing Submarine Launched Intermediate Range Ballistic Missile (SLIRBM).[124] The range of the SLIRBM would be substantially less than Trident.

Contractors were asked to look at nuclear as well as conventional payloads. The design is required to fit into a Trident launch tube, diameter 86 inches, although the new missile was to have a diameter of less than 32.5 inches. The maximum missile length was 36 feet. The potential deployment of these missiles on surface ships was also to be explored. SLIRBM is a system that could be deployed on a future hybrid submarine. This concept is at an early stage. There will be a continued emphasis within US nuclear policy on attacking Russia. For this reason SLIRBM will not replace intercontinental sea-launched missiles, such as Trident. It is unlikely that SLIRBM will be funded in addition to longer-range missiles.

Air-launched missiles

In the 1980s the US, Britain and France all considered there was a need to develop short-range air-launched nuclear missiles. Aircraft carrying gravity bombs were likely to be shot down by Warsaw Pact Air Defences, whereas these missiles could be fired at targets several hundred kilometres away. The US designed the Short Range Attack Missile –Tactical (SRAM-T), a variant of the SRAM-2 missile. SRAM-T was to use the W91 nuclear warhead. In 1990 there was opposition in Congress to continuing to fund SRAM-T on the grounds that it would not be required in the post Cold War world. The following year both SRAM-2 and SRAM-T were cancelled.

Britain had planned to replace the WE-177 freefall bomb with a Tactical Air to Surface Missile (TASM) and considered three alternatives. SRAM-T was the obvious choice. A second US possibility was the Supersonic Low Altitude Target drone (SLAT). The third option was a joint Anglo-French design, the Air Sol Longue Portee (ASLP). In 1990 the MoD awarded a £1 million contract for a pre-feasibility study into a version of ASLP with a range of 500 km. A summary of papers in the public records office says that the weapon to replace WE 177 was designated TD 127.[125] TASM was scrapped because it was obsolete before it was built. Before this decision was announced a Labour spokesperson said, “the Labour party would scrap TASM tomorrow” and save £3 billion.[126]

Sir Jock Stirrup, Chief of the Air Staff, is reported as advocating that a nuclear warhead should be fitted to air-launched missiles on the new Typhoon aircraft.[127] The experience of TASM illustrates that it is not practical for Britain to develop a nuclear system where there is no American counterpart. The air-launched nuclear missiles in service in the USAF are carried by B52 bombers. There is no operational American nuclear missile that can be carried by short-range fighter-bombers.

Freefall bombs

Aircraft with freefall bombs are vulnerable to surface to air missiles and other air defences. Since the early days of the nuclear age the RAF has known that there would be substantial losses in a nuclear bombing raid. In recent air offensives, against Kosovo and Iraq, the first stage has been attacks on air defence sites, primarily using cruise missiles. The main bombing raids are only launched days or week later. A nuclear raid with freefall bombs could only be reliably carried out in the second phase of a sustained attack. US policy does not regard this as sufficient. The emphasis within Global Strike is on very rapid nuclear action. The US Air Force is able to launch attacks with freefall nuclear bombs at short notice using B2 bombers, which are not detected by radar defences. The RAF does not have any equivalent capability and to develop long-range stealth bombers would be very expensive.

Developing a freefall nuclear bomb may be regarded as a simple option for the MoD. However the capability of such a weapon would be limited. Nuclear capable Tornado aircraft have been deployed by the RAF and are currently in service with the German and Italian Air Forces. However there are no plans to develop a nuclear capable version of the new Eurofighter.

Shared use of US aircraft bombs

Four European members of NATO have squadrons of aircraft that could launch an attack with US nuclear bombs. If the reality of nuclear dependence were acknowledged and it was accepted that Britain would only ever use nuclear weapons in support of an American operation, then it would be far cheaper to go down the road of these European allies. A small number of RAF aircrew could be trained to drop US nuclear bombs, which would normally be stored under US control.

Consideration of this option reveals the absurdity of all Britain’s future nuclear alternatives. In many ways borrowing US bombs could be presented as a more logical course. But the reality is that the American bombs in Europe are no more than a legacy of the Cold War, with no contemporary relevance.

Future warheads

Aldermaston designed and tested a range of nuclear weapons in the 1950s and 1960s, but these designs would not comply with modern safety and reliability criteria. The US upgrade of the W76 suggests that the safety systems on the UK Trident Re-entry Body (RB) should be replaced. Britain has developed an Insensitive High Explosive, EDC 35, but Britain has not tested a design that uses it. The development of a warhead for TASM reached an advanced stage.[128]

The ban on testing that is currently practiced, supported by the Comprehensive Test Ban Treaty, constrains the development of new nuclear weapons. The Advanced Simulation and Computing project in the US aims to benchmark existing systems by 2010. Beyond then it might provide the capability of verifying new weapons, within the bounds of safety and reliability. But there are signs that if the US had to introduce a new weapon then a nuclear test would be carried out.

Aldermaston will expect to build on existing co-operation to secure the future of upgrades to Trident. Developing Anglicised versions of other US designs would require the release of new information and a greater level of support. This might not be forthcoming.

Materials

Nuclear weapons require tritium. The production of tritium for British nuclear weapons at Chapelcross ceased in 2004.[129] The Government has said there is enough tritium to satisfy the requirements of the Trident system throughout its life. Substantial quantities of tritium were produced at Chapelcross and more was recovered from Chevaline and WE-177 warheads. The tritium reserve may be large enough to restock the warheads until 2024 but by then the reserve would be almost exhausted. Both Britain and the US have operated on the basis that a large reserve of tritium is essential.

If the Government decided to retain a nuclear capability for the longer term, then it is likely that securing a source of tritium would be a priority. Finding a domestic supply will be linked to the future of the civil nuclear industry. The Chapelcross Production Plant, which was run by the MoD will shortly be decommissioned.[130] A new plant would be expensive as it would need to operate with higher safety standards than the old facility. Building a tritium facility next to an existing or a new nuclear power station would be a key part of any long-term plans to sustain a nuclear weapons capability in Britain. The US has in the past supplied tritium to Britain. Buying or bartering tritium from America could be a future option, but it would raise the issue of dependence.[131]

A second key material is Highly Enriched Uranium (HEU). Trident and other Royal Navy submarines are nuclear powered. Their reactors are fuelled by HEU, enriched to around 98 %. Britain cannot enrich HEU to this degree and the task is carried out in the US.[132] In recent years stocks of HEU for the submarine programme have been low. This will be a critical element of any future submarine-based nuclear weapon system.

Relationship between nuclear options, dependence and purpose

Should Britain have a nuclear force so that this country can contribute to an Anglo-American global strike at short notice? Is Britain is willing to continue in the nuclear business, on the basis of supporting US nuclear operations? The extent to which British forces would be seen as an independent force has a bearing on considering the options. If it were acknowledged that the most likely scenario is that British nuclear weapons are used as a small part of an American nuclear attack, to internationalise it, then this could be achieved with a small number of weapons. The choice of system would then be one compatible with what the US is most likely to use. For Global Strike operations the US weapon of choice would be the B2 bomber, but this is unlikely to be an option for Britain.

If the main emphasis is on Wider-Threat / non-Russian scenarios, then Trident has significant disadvantages. Its use in any situation might trigger a Russian nuclear response. Against hypothetical new threats the desire is to have weapons with a low yield and high accuracy. Sea-launched cruise missiles, air-launched missiles and freefall bombs might be presented as suitable options, but it is hard to avoid the fact that these have all been rejected in the past. Freefall bombs were regarded as too vulnerable to air defences. Tactical air-launched missiles were designed for use on a European battlefield against the armies of the Warsaw Pact. The US and Britain both decided in the early 1990s against proceeding with these Cold War weapons. Sea-launched cruise missiles were rejected as an option in the British discussions in the late 1970s. They are not an important part of US nuclear forces today and cannot be deployed at short notice.

The assessment of what constitutes a “minimum” deterrent, and the issue over whether Russia remains part of the calculation also has a bearing on these options. Trident may be sustained on the basis of the Moscow criteria. If the decision is to have a system that can be used in an independent attack this may result in more weapons with greater capability and cost

Britain will only be able to buy what the US is willing to put up for sale. The Whitehouse will have a powerful voice in the selection of future systems.

The non-nuclear option

There is no coherent rationale for British nuclear weapons, yet there are substantial risks involved in retaining them. The limited practical options and the issue of dependence further constrain any arguments that might be made. There are substantial benefits that would flow from not replacing Trident. This would send a message that Britain takes seriously its obligations under the Non Proliferation Treaty and would contribute to tackling proliferation. It would reinforce the taboo on the use of nuclear weapons and free up valuable financial resources. It would also signal that this country is not willing to support an aggressive US nuclear posture.

Notes

1. Robert Fox, Trident: the done deal, New Stateman, 13 June 2005
2. Patrick Wintour & Martin Kettle, Britain faces long-term nuclear threat and must plan for it, says Reid, Guardian 13 September 2005
3. The future of the UK strategic deterrent, RUSI,conference, 6 July 2005.
4. The warheads are being refurbished from 2005. The plan is probably for 12 years service before and after this. Annex I. The 25 year contract for AWE (2000-2025) "covers the expected life of the Trident system", AWE annual report 2002.
5. Lawrence Freedman, Britain and Nuclear Weapons, Macmillan, 1980, p 52f
6. RUSI deterrent conference. John Reid has said that it will not be possible to avoid a debate.
7. Polaris Sales Agreement 1963
8. Solly Zuckerman, Monkey, Men and Missiles: an autobiography 1946-88, Collins, 1988, p254.
9. Similar views were expressed in 1961 by Cabinet Secretary Sir Norman Brook who said "there is no great need for an independent British contribution to the strategic nuclear deterrent of the West", Memorandum by the Secretary of the Cabinet, 18 Jan 1961, "Some Aspects of Our Relations with the United States", File 52665, CAB 133/244 PRO, in Midshipman J B Solomon, The Multilateral Force: America's nuclear solution for NATO (1960-1965) 1999, US Naval Academy Annapolis.
10. Draft of a letter from President Kennedy to the US Ambassador in Paris, May 1963. The letter was never sent. Ian Clark, Nuclear Diplomacy and the Special Relationship, 1994, p 300.
11. The State Department argued that Johnston should facilitate Britain's withdrawal from the Polaris Sales Agreement. However Wilson had no intention of pulling out from the deal.
12. C Poppe et al, Whither Deterrence, LLNL, 2002. It has been suggested that the US Air Force could find itself bombing nuclear facilities in Iran, to pre-empt an Israeli raid on these targets.
13. Jonathan Schell, The Gift of Time, Granta, 1998, p129.
14. Ministry of Defence, Strategic Defence Review, July 1998 para 55
15. Donald Rumsfeld, Secretary of Defense, National Defense University, 31 January 2002,
16. For example, "The presence of international players increases the legitimacy of WMD elimination efforts", US Joint Doctrine for Combating WMD, JP 3-40, 8 July 2004.
17. When asked by Angus Robertson MP to name the country where neutron generators for Trident were built, Adam Ingram MP said: "I am withholding the information requested under Exemption 1 (defence, security and international relations) of the Code of Practice on Access to Government Information", Hansard, 8 July 2004.
18. Operational Selection Policy OSP11 Nuclear Weapons Policy 1967-1998, Public Records Office

19. Frances Pym, Defence Minister quoted in Tim Garden, Can Deterrence Last, Chapter 4 British Nuclear Strategy; www.tgarden.demon.co.uk

20. MoD Strategic Defence Review, Supporting Essay 5.

21. Ministry of Defence, The Strategic Defence Review: A New Chapter, July 2002

22. Michael Quinlan, Nuclear weapons and the abolition of war, International Affairs 67,2 (1991) p294.

23. ibid p 295

24. Malcolm Rifkind, UK Defence Strategy; a continuing role for nuclear weapons, speech on 16 November 1993, para 13

25. "There is no basis for speculation on what contingency planning may secretly be undertaken within the Ministry of Defence or operational headquarters. It is possible, given now the very general 'to whom it may concern' character of UK nuclear deterrence, that there is currently little or no such planning in specific terms". Michael Quinlan, The British experience, in HD Sokolski Ed, Getting MAD, November 2004, p274.

26. What is the role of Trident, NS(Det)1, Rolling brief, Commander Naval Staff, November 2003.

27. Rifkind op cit

28. David Omand, Nuclear Deterrence in a Changing World, RUSI Journal, June 1996, p 21

29. Jonathan Dimbleby programme, London Weekend Television, 24 March 2002, Media Transcription Service.

30. Speaking about states like Iraq, Geoff Hoon said: "They can be absolutely confident that in the right conditions we would be willing to use our nuclear weapons." Defence Committee, 20 March 2002.

31. Tim Hare, What next for Trident, RUSI Journal April 2005

32. Michael Clarke, Does my bomb look big in this, International Affairs, Feb 2004

33. Trident is not well suited for a limited nuclear attack. The US would probably use B2 bombers. See Annex H

34. Doctrine for Joint Nuclear Operations, JP 3-12, Final Coordination (2), 15 March 2005.

35. Hare op cit

36. The Defence Committee has said the Government should not accept the US approach to pre-emption Report on the Defence White Paper 2003, House of Commons Defence Committee, 5th report of 2003/04, HC 465-1

37. Commander Naval Staff, Rolling Brief

38. Rifkind op cit

39. Commander Naval Staff, Rolling brief.

40. Polaris Sales Agreement 1963

41. Michael Portillo, Does Britain need nuclear weapons ? No. The Times, 19 June 2005

42. Fox op cit

43. Quinlan Abolition of War

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45. www.dadalos.org/frieden_int/grundkurs_2/krieg.htm

46. US coercion in a world of proliferating and varied WMD capabilities, a study for the Defence Threat Reduction Agency by DFI International/Sparta, February 2001.

47. GC Buchan et al, Future roles of US nuclear forces, RAND, 2003, p37

48. General Lee Butler, Death by Deterrence, Resurgence 193 March/April 1999

49. Buchan op cit

50. Statement by Michael Quinlan to the House of Lords Foreign Affairs Committee 29 January 2000; Speaking for the Government Lord Gilbert used the same phrase, Hansard 1 July 1999.

51. C Paul Robinson, A White Paper: Pursuing a new nuclear weapons policy for the 21st century, SNL, 22 March 2001.

52. Michael Quinlan, The British Experience, in HD Sokolski Ed, Getting MAD, November 2004.

53. Bruce Blair in Schell op cit, p79

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55. Schell op cit, p 69

56. Schell, op cit,p 130

57. P Hayes & N Tannenwald, JASON study reported in Nixing Nukes in Vietnam, Bulletin of Atomic Scientists, May/June 2003

58. ibid; Referring to the views of Herman Kahn,

59. General Charles Horner, Former Commander of US Space Command, in Schell, op cit, p 39

60. Hare op cit

61. Robin Cook, Replacing Trident is against both our national interests and our international obligations, Guardian, 29 July 2005; Portillo op cit.

62. Schell, op cit, pxi

63. ibid, p200

64. ibid, p188

65. Geneva Convention 1949 Article 48.

66. Quinlan Abolition of War

67. ibid, quoting MoD evidence to the Defence Committee 4 November 1980

68. ibid.

69. John Ainslie, Trident: Britain's Weapon of Mass Destruction, Scottish CND, March 1999.

70. Advisory Opinion on the Legality of the Threat or Use of Nuclear Weapons, International Court of Justice, 8 July 1996, para 105 (2)

71. President Bedaoui, International Court of Justice, 8 July 1996

72. Buchan op cit p xv

73. Butler Death by Deterrence

74. Schell, op cit, p184f

75. ibid, p 47

76. Essentials of Post War deterrence, Strategic Advisory Group, 1995, obtained under the FOIA by H Kristensen

77. Ainslie op cit

78. Lee Butler reported "One of the exercises I asked my staff to go through was to remove all the weapons directly targeted on Moscow and just calculate radiation levels in the city by looking at the strikes upwind of the city in various climatological scenarios. The result was exactly as I would have predicted: the city was rendered uninhabitable for generations". Brian Hall, Overkill is not dead, New York Times, 14 March 1998. An NRDC report also showed that the fallout from a US attack on Russian nuclear weapons sites would result in massive civilian casualties, McKinzie op cit.

79. DE Mosher et al, Beyond the nuclear shadow: a phased approach for improving nuclear safety & US-Russian relations, RAND, 2003

80. ibid p xvii

81. ibid p xx

82. RUSI Deterrence Conference

83. The unresolved questions in British nuclear policy in the early decades are outlined in John Baylis, Ambiguity and Deterrence, British Nuclear Strategy 1945-1964, OUP, 1996

84. Defence Committee Minutes of Evidence 19 January 2000.

85. No way out for Saddam – Blair, The Guardian, 21 January 2003, quoted in M Butcher, What Wrongs our arms may do, the role of Nuclear Weapons in Counterproliferation, Physicians for Social Responsibility, August 2003

86. Essentials of Post War Deterrence, p7

87. Schell, op cit, p 50

88. Schell, op cit, p162

89. Ian Clark, Nuclear Diplomacy and the Special Relationship, 1994, p368

90. ibid, p 368, 389

91. Hansard 9 November 1998

92. Initially each Polaris missile had 3 warheads, with Chevaline this was reduced to 2. In both cases the warheads on one missile could not be separately targeted

93. Hansard 9 November 1998

94. For months after the end of a refit there are only 2 operational submarines. This is the case throughout 2005

95. M Clarke op cit

96. "as a sign of national resolve and readiness the number of ICBMs on alert may be increased and SSBNs may be deployed to dispersal locations". Joint Staff Input to Doctrine for Joint Nuclear Operations, JP 3-12, 28 Mar 2003.

97. The British View of the Strategy for the Defence of Central Europe, DEFE 4/141, JP (62) quoted in Baylis op cit

98. US and UK Studies of the Use of Tactical Nuclear Weapons, DEFE 4/157, 15 August 1963; Baylis, op cit, Appendix 13

99. Schell, op cit, p131

100. Rifkind op cit

101. Robert Norris, Andrew Burrows & Richard Fieldhouse, British, French and Chinese Nuclear Weapons, Nuclear Weapons Databook Vol V, NRDC 1994.

102. In his introductory statement Mr Rifkind said - "I intend to show why the possession of nuclear weapons by the United Kingdom, in the context of a European contribution to the North Atlantic Alliance, can and should continue to make a positive and necessary contribution to security." Rifkind, op cit

103. House of Lords 1 January 1999.

104. Commander Naval Staff, Rolling Brief,

105. RUSI deterrence conference

106. Hare op cit

107. The first orders for rocket motor components for D5 LE were placed in 2002.

108. Statement by Rear Admiral Charles B Young, Director Strategic Systems Programs before the Strategic Subcommittee of the Senate Armed Services Committee, 8 April 2003.

109. The life of conventional armed Los Angeles Class submarines has only been extended to 33 years.

110. Nuclear Posture Review

111. Core H has been on test at HMS Vulcan, Dounreay since 2000.

112. Written answer by Geoff Hoon MP, 30 June 2004 in reply to a question by Paul Keetch.

113. An SSN/SSBN hybrid submarine is likely to carry fewer missiles than Vanguard class, although it would be possible to carry similar numbers of warheads. .

114. A critical factor is the life of the high explosive in British warheads, probably 12 years, See Annex I

115. Hare op cit

116. See Annex F

117. Lt Comdr Guy B Reynolds, The nuclear-armed Tomahawk cruise missile: its potential utility on United States and United Kingdom attack submarines, Naval Postgraduate School, Monterey, December 1998, p30

118. ibid

119. The US Navy can deploy TLAM-N on submarines within 30 days and this is tested each year. A limited number of US submarines are fitted with the equipment needed to launch TLAM-N. A new portable launch system, AN/BGS-1, has been developed and is being introduced slowly. It can give any submarine on which it is installed the capability to fire TLAM-N.

120. US budgets and other documents refer to W80-3, the upgrade of the air-launched version. There is virtually no mention of W80-2, the planned upgrade to the sea-launched version.

121. Reynolds op cit

122. Future Strategic Strike Force, Defense Science Task Force, February 2004, p 5-13

123. TLAM-N may be phased out by 2010, C Poppe et al, Whither Deterrence ,LLNL, 2002, p 33f; There is only funding for TLAM-N until FY2009, Future Strategic Strike Force, Defense Science Task Force, February 2004, p5-8. “the long term rationale and support for TLAM-N is uncertain at best” – Defence Science Task Force on Nuclear Deterrence, October 1998.

124. Federal Business Opportunities, 22 Aug 2003. In 2004 further studies were initiated into possible rocket motors for SLIRBM, N00030-05-R-0042 Federal Business Opportunities, 22 Oct 2004

125. Operational Selection Policy OSP11 Nuclear Weapons Policy 1967-1998, Public Records Office; TD 127 This may either be the UK designation of ASLP or of the warhead. Two letter, three number designations are used for both missiles and nuclear warheads.

126. Martlew, Hansard 9 February 1993.

127. Fox op cit.

128. The TASM warhead may have been similar to the US W91 or W61.

129. In the year before Chapelcross power station closed the Ministry of Defence lobbied the Nuclear Installations Inspectorate, unsuccessfully, to restart the reactors because they wanted to increase reserves of tritium.

130. There is in addition a new tritium research facility at Aldermaston.

131. Tritium for both British and US warheads is handled at the Savannah River Site in America. In the 1990s the US had no facility to produce tritium. However they did not need to use British tritium as they were obtaining large quantities of the material from warheads decommissioned since 1991.

132. In 1980 it was planned that part of the HEU requirement for Trident would be produced at Capenhurst and a second part procured from the US. In 1982 the plan was altered to a two stage process using both Capenhurst and Portsmouth, Ohio, US. Final enrichment was carried out at the American facility. Hansard 23 Jun 1982 col 128, 23 July 1993 col 127.

Annex A

United States Nuclear Policy

The Old Enemy

According to President George W Bush, "Russia is not our enemy".[1] Condaleeza Rice has said "America's security is threatened less by Russia's strength than by its weakness and incoherence".[2] Today's problems are the conflict in Chechnya and the danger of Russian nuclear weapons falling into the hands of terrorists. In 2001 the Nuclear Posture Review (NPR) said, "The U.S. will no longer plan, size or sustain its forces as though Russia presented merely a smaller version of the threat posed by the former Soviet Union."[3]

However these statements mask the extent to which Russia remains the real focus of the US nuclear posture. The planners are still concerned about Russia's strength. It is "the only nation that we can conceive of with the potential to threaten the US national existence".[4] Bruce Blair, Director of the Centre for Defense Information, says of the Russian issue – "The dirty little secret of America's current nuclear policy is that 99 percent of the nuclear weapons budget, planning, targeting, and operational activities still revolves around this one anachronistic scenario".[5]

Planners assume that relations with Russia will change only slowly.[6] They think that Russia will retain a substantial nuclear arsenal, but is unlikely to become a peer competitor with the US.[7] It has been suggested that Russia might try to improve its conventional forces.[8] Paul Robinson, as Chair of the Strategic Advisory Group, uses the term Capability One to describe Central Deterrence, the main focus of which will continue to be Russia.[9] For this America will continue to have forces on short notice to deter any possible sudden attack, try to reduce the stockpiles of strategic nuclear weapons held by each side, and retain a "hedge". This hedge is an ability to rearm should the threat from Russia increase.

The NPR adopts a capabilities-based approach.[10] The US will prepare to respond to the types of forces an enemy may have, rather than to specific adversaries. But the scale of the potential threat from Russia is unique. The capabilities-based approach only really applies to wider threats.

There have been calls for a more radical realignment of US nuclear forces. A review of Future Strategic Strike Forces calls for weapons systems to be modified so that they are more suitable for use against new

WMD threats. It says that plans to develop low-yield weapons should be accelerated and there should be new conventional weapons for long-range strategic attacks. It advocates cutting back spending on high-yield weapons to pay for the new capabilities. This criticism of the NPR shows that it was not the radical document that it claimed to be.

The vast majority of the nuclear weapons budget from 2005 to 2009 is allocated to sustaining existing high-yield weapons. Although the numbers are falling, there is no substantial adjustment of the types of nuclear forces. Current US strategic nuclear forces remain designed for use against Russia, while some of these forces could also be used in a Counter Proliferation role.

Paul Robinson said that the US "employs a counterforce strategy that targets military assets that could inflict damage on our national interests".[11] The NPR said that US nuclear weapons would be targeted on "leadership and military capabilities, particularly WMD, military command facilities and other centres of control and infrastructure that support military forces".[12] The counterforce strategy has been described as one of damage limitation.[13] The aim would be to destroy a large proportion of Russian nuclear forces before they were launched, in order to reduce the damage they would inflict. Attacks would also be made on command, control and communication sites to prevent the missiles being launched. In practical terms it is a short step from having a robust damage-limitation capability to having a first strike force, which is ready to destroy Russian nuclear forces before an attack was launched. There is also a distinction between whether US forces are on a "launch on attack" or a "launch on warning" status. Rather than waiting for the first Russian warhead to explode, forces are more likely to be on "launch on warning" readiness, i.e. a US launch would be authorised when a missile launch was detected by satellite or radar systems.[14]

There were four major options for attacking Russia in the 1999 edition of the Single Integrated Operation Plan (SIOP).[15] Major Attack Option 1 (MAO-1) targeted all Russian ICBM silos, SLBM bases, mobile ICBMs, nuclear airbases and other key nuclear weapons sites. There were between 1,000 and 1,200 targets in this option. Some would have been attacked with more than one warhead. MAO 2 included all the targets in MAO-1 plus conventional military targets. MAO-3 added to this leadership targets, and MAO-4 added key economic facilities. The reductions planned in the Moscow agreement are likely to mean that MAO-2 and MAO-4 would not be feasible without reactivating the responsive force. The focus today is probably on MAO-1 with the potential to add leadership targets.

The number of operational strategic nuclear weapons is falling as a result of the Moscow Agreement. But this lacks the status or detail of earlier arms control treaties. One of the principles of arms reductions is "irreversibility" – weapons that have been eliminated under a treaty should be destroyed. This principle is ignored in the Moscow Agreement. The US will place surplus warheads in a reserve, the "responsive force". This large reserve can be reactivated should the need arise. The US is prepared to breach the Moscow Agreement to do so.[16]

US plans for Missile Defence will have an impact on the effectiveness of a second-strike counterattack from Russia. There is some concern in Russia that after 2012 the US could break out of nominal parity with Russia and seek to achieve clear superiority, backed by substantial ABM defences.

Wider Threats

To whom it may concern

As the Cold War ended Strategic Command (STRATCOM) looked around to find new roles to justify sustaining the vast US nuclear establishment. In 1993 the focus of US nuclear strategy extended beyond Russia to include "any potentially hostile country that has or is seeking weapons of mass destruction."[17] Paul Robinson defined two nuclear capabilities: Central Deterrence and Deterrence of Wider Threats.[18] The latter would deal with countries, other than Russia, which possessed, or might try to acquire WMD. Robinson called the nuclear weapons allocated to this new threat the "To Whom It May Concern" force. An earlier example of this approach was the French idea of "a tout azimuth". It was proposed that French nuclear weapons were not for use against one clearly defined foe, but might be used against any nation.

Counter Proliferation

Two terms are used to describe moves to prevent countries from developing Weapons of Mass Destruction (WMD): Non-Proliferation refers to diplomatic moves, Counter Proliferation includes the use of military force. There is considerable overlap between the two.

In the US there is substantial emphasis on the Counter Proliferation approach. This includes nuclear doctrine. In US policy Counter Proliferation involves more than just responding to countries that have WMD programmes. They also seek to discourage nations from acquiring these weapons. In pursuing this approach the US is prepared to act unilaterally and to pay limited attention to international law and institutions.

During the Gulf War of 1991 the US military were worried about Iraq's chemical weapons, although they were never used. Following this conflict there was concern that in future America's enemies, confronted with overwhelming conventional firepower, would develop nuclear, chemical or biological weapons.[19] There were calls to improve defences against Chemical or Biological attack, and to develop ways of attacking potential WMD targets.

A review of US nuclear policy began in October 1993. Dr Steven Fetter, a key member of the review team, argued that nuclear weapons could play no role in countering chemical or biological weapons. However STRATCOM moved effectively to counter his concerns. The review concluded that nuclear weapons could play a unique role, and that the full range of nuclear options should be available against states which sought to acquire WMD.[20]

The Doctrine for Joint Theatre Nuclear Operations 1996 referred to targeting new WMD threats.[21] It described missiles capable of carrying WMD as the primary threat. The Doctrine for Joint Nuclear Operations, 2005, focuses on WMD threats.[22] WMD are defined as nuclear, chemical, biological or high explosive weapons "that are capable of a high order of destruction and/or of being used in a manner as to destroy large numbers of people".[23] The draft Doctrine mentioned two scenarios. One was that an adversary would detonate a nuclear weapon above the atmosphere in order to exploit the vulnerability of US.[24] Another was that a WMD could be used to force the US to withdraw following an invasion, or against ports or airfields to prevent US reinforcements from being deployed. The latter scenario was omitted from the revised version of the Doctrine.[25]

Studied ambiguity

While making clear what action America wanted to prevent, the US is urged not to be plain about how it will respond. - "We must be ambiguous about details of our response (or pre-emption) if what we value is threatened, but it must be clear that our actions would have terrible consequences."[26]

This policy of "studied ambiguity" may be based on concern about a "commitment trap". If a threat was specific and clear, the US might, in due course, feel compelled to carry out it out, even though it was not in America's interest to do so. It would be paramount that the US did not make idle threats, as this would send the wrong message to all potential enemies. Another reason for ambiguity is concern about public opinion in the US and around the world. A vague statement is likely to cause less of an outcry than a clear threat to use nuclear weapons against specific targets.

Paul Robinson recognises that "studied ambiguity" may not be sustainable in the long term. He described how the Clinton Administration had made preparations to use nuclear weapons for Counter Proliferation, while never disclosing that this was their policy. He added that they had not considered the full implications of "studied ambiguity".

The nature of the new deterrence

The Strategic Advisory Group has been central to the development of US nuclear policy. In 1995 it produced a report on the "Essentials of Post-Cold War Deterrence".[27] This considered how to deter countries, other than Russia, from using WMD. The report emphasises that deterrence operates at an emotional as well as a rational level - "deterrence must create fear in the mind of the adversary – fear that he will not achieve his objectives, fear that his losses and pain will far outweigh any potential gains, fear that he will be punished. It should ultimately create the fear of extinction – extinction of either the adversary's leaders themselves or their national independence, or both".[28]

It highlights the need to identify what is highly valued by the opposing leader, and then to threaten to destroy it. It tells a story from Lebanon. When several Soviet citizens were kidnapped and killed, the Russians sent the leader of the revolutionary group a package containing the testicle of his eldest son. The story concludes that never again did the group attack any Russian citizen.

The report lists normal types of targets for nuclear weapons - military capabilities, war-supporting industry and the national leadership. But it also hints at other potential targets. Whatever was highly valued, whatever was a symbol of the ruling regime, could be attacked with nuclear weapons. The NPR says, "The assets most valued by the spectrum of potential adversaries in the new security environment may be diverse."[29] The values of these new adversaries would be different from those of Russia, and they could have different views on what was an unacceptable loss.

"Essentials of Post-Cold War Deterrence" warns against the US appearing too rational. It advocates an approach based on fear, and suggests that to appear to be irrational and vindictive might be beneficial - "That the US may become irrational and vindictive if its vital interests are attacked should be part of the national persona we project to all adversaries."[30]

Targeting specific threats

In January 1991, just before the start of the first Gulf War, Defence Secretary Dick Cheney issued a Nuclear Weapons Employment Policy. This set in motion a process to prepare plans for using nuclear weapons against countries which might be developing WMD.[31] The change was implemented in the 1993 version of the nuclear war plan, SIOP 93. Russia and China remained the main focus of the plan but other countries, which might be building WMD, were added to the target list.

In April 1993 STRATCOM drew up plans to use nuclear and conventional weapons in "silver bullet" strikes on nuclear, chemical and biological targets, as well as command and control sites, in the "rogue states". These were called Strategic Installations List of Vulnerability Effects and Results, or Silver Books. Regional commanders opposed the role that STRATCOM was taking and the Silver Books project was scrapped.[32] This was only a temporary setback to STRATCOM's goal of playing a key role in counterproliferation.

In 1995 STRATCOM was asked to simulate what would happen if a nuclear-armed Iran attacking its neighbours in 2015. They were unable to complete the study and the project was revised to simulate an attack from North Korea.[33] In 1996 American officials revealed that plans had been drawn up to use the new B61-11 nuclear bunker-buster bomb against the Tarhunah chemical weapons plant in Libya. This was a rare disclosure of the targeting of nuclear weapons against a specific target.

Paul Robinson revealed that military planning had moved ahead of the policy making process. Theatre Commanders had identified potential WMD targets and plans had been drafted to attack these installations with nuclear weapons. But, he says, there was no coherent policy process behind this military planning – "There has been no clear policy in place – I can even say there has been a lack of clear thinking in place – regarding 'limited nuclear attacks'".[34]

The NPR listed as an Iraqi attack on Israel, a North Korean attack on South Korea, and a conflict over Taiwan as "immediate contingencies" in which nuclear weapons might play a role. "Potential contingencies" included a new threat to the US from a state or states with WMD. "Unexpected contingencies" included regime change in a country with WMD.

The Universal Joint Task List shows that US forces are expected to be able to detect a percentage of all Nuclear, Chemical and Biological production, storage and weapon systems of all potential enemies.[35] US Counter Proliferation strategy is based on the ability to identify these targets. But the failure of Western intelligence to accurately access Iraq's WMD capability showed how difficult this is.

Nuclear weapons and terrorism

The 1994 US review of nuclear policy concluded that nuclear deterrence should not apply to terrorists, when they were not state-sponsored. Nuclear weapons would not effectively deter them.[36] Terrorist groups are small and dispersed. They would not present suitable targets. However where a terrorism group is supported by a state, particularly where the state may provide WMD to the terrorist group, then that state may become a nuclear target. This has become a particular focus for US strategists, including nuclear planners.[37]

Since 2001 there has been increased emphasis on terrorists attacking America with WMD. The US National Security Strategy 2002, said - "terrorist groups are seeking to acquire WMD with the stated purpose of killing large number of our people".[38] The Doctrine for Joint Nuclear Operations says that nuclear weapons can deter both terrorists who want to acquire WMD and also states that might support them. It adds that there is an increased probability that a state, a non-state actor or a terrorist might use WMD. It says that if deterrence fails the US is prepared to use nuclear weapons.[39]

The budget for Financial Year (FY) 2004 refers to studies conducted in support of nuclear operations.[40] Similar studies were funded the following year, with added references to the war on terror. The European Theater Nuclear Support Program provides support for US forces in Europe and NATO and "towards the war on terrorism". The War Plan Support Program responds to requests from Combatant Commands for assistance with dealing with WMD challenges, "particularly the war on terrorism".

Full Spectrum Global Strike

The new mission of STRATCOM is full spectrum global strike.[41] Global strike is the ability to attack a target anywhere in the world at short notice. Full Spectrum refers to all possible forms of attack – nuclear, conventional and non-kinetic. Non-kinetic refers to electronic, information and psychological operations. The computer systems in Omaha can draw up plans for long-range attacks with conventional weapons, although the main emphasis remains nuclear planning.

On the one hand "Global Strike" encompasses all aspects of STRATCOM's nuclear planning. On the other, the term is used particularly for the capability to launch attacks at short notice at new targets, out-with OPLAN 8044. The Global Strike Contingency Plan, CONPLAN 8022, came into effect in April 2003.

During the Cold War, large numbers of US nuclear bombers were fully armed and ready to take off. This alert posture ended in 1991. While it has not been revived, Global Strike has meant that the bombers are on a new alert. In late 2004 the commander of the 8th Air Force said that his B-2 and B-52 bombers could execute a Global Strike attack in half a day or less.[42]

A Global Strike nuclear attack would be most likely to use B-2 bombers based at Whiteman Air Force Base (AFB) in Missouri and armed with B61-7 or B61-11 bombs.[43] The B-2 is an advanced stealth bombers and is less vulnerable to air defences than other aircraft. There are a total of 21 of these aircraft, 16 are likely to be combat ready, of which 7 are available at any time.[44] Each B2 bomber can carry eight B61-7 or five B61-11 bombs.[45] The B61-11 is designed for use against hardened targets and has an estimated yield of 400 kilotons. The B61-7 has four yield options, the highest is 350 kiloton and the lowest is less than 1 kiloton.[46]

B-2 aircrews are certified for nuclear missions.[47] They also practice conventional attacks against targets around the world, in Global Power exercises. They have been used to bomb Iraq. Large hangers have been built so they can be maintained at forward locations. There is one hanger at RAF Fairford in England and four hangers at Deigo Garcia in the Indian Ocean. There may also be one in the Middle East. The B-2 force is allocated targets in the main plan for a nuclear attack on Russia.[48]

Targeting China

By far the largest number of targets for US nuclear weapons is in Russia. But this number has declined. At the same time the proportion of the targets which are in China has increased. According to the NPR a nuclear contingency involving China is more likely than one involving Russia.[49] The most likely scenario mentioned is a military confrontation over Taiwan. In 1995, following friction over exercises near Taiwan, China said they had nuclear weapons that could destroy Los Angeles.[50]

US plans for Missile Defence are a problem in China for two reasons. Bejing is concerned that America will provide Theatre Missile Defence cover for Taiwan. Secondly, the Chinese regard plans for a Missile Defence for the USA itself as primarily a counter for their nuclear force. Technologically China is on the verge of having nuclear missiles that could launch a major attack on the US. However it is by no means clear that Beijing wants to spend substantial amounts of money on this.

The US is upgrading Trident submarines in the Pacific with longer-range D5 missiles. The balance of Trident deployment between the Atlantic and Pacific fleets is being adjusted, with an increase in the proportion in the Pacific. The US Universal Joint Task List refers to the "Probability of success for pre-emptive attacks on minor nuclear powers". This measure is likely to include China and is quantified as a percentage.[51]

Projections of future threats to the US anticipate that China will become a more powerful economic competitor and might become a major nuclear rival. This is reflected in the NPR, which says China could be involved in a potential contingency. To deal with potential contingencies the NPR explains that large numbers of nuclear weapons, which have been removed from operational status, will be kept in reserve in a "responsive force". One reason that the US is holding on to a huge reserve is the fear that China will increase its nuclear capability.

China is aware of the direct references made to it in the published extracts from the NPR. The proposed Robust Nuclear Earth Penetrator is also regarded, by some in Beijing, as a weapon designed for use against China's underground facilities. The new posture in the NPR is interpreted as a plan to ensure that the US is able to launch an effective first strike which could destroy China's nuclear arsenal.

US commentators have suggested that China might make an asymmetric response than to engage in an arms race with the US. They are worried that China might encourage the proliferation of WMD and missile technologies as a response to US Missile Defence plans.

Estimates of the size of China's nuclear forces vary. China's nuclear policies and strategy are also not well understood. One US report warns: "If the strategic views of China and the United States are really fundamentally different, a collision that no-one wants could result from misunderstanding and miscalculation."[52]

Warfighting and "useable" weapons

The term "warfighting" is used widely by the US military and is applied in the nuclear field. Part of the mission of STRATCOM is to provide "specialized planning expertise to the joint warfighter".[53] STRATCOM see themselves as nuclear warfighters, not only with regard to wider threats, but also in relation to Russia. Their report into the implications of START II had the title - "Post START II Arms Reductions Warfighter's Assessment".[54]

The Strategic Advisory Group, in a reference to Russia's mobile ICBM, said – "as warfighters we find them difficult (and expensive) to counter …. USSTRATCOM, as the warfighter, should continue to pursue methods of countering strategic mobiles."[55] There is a conflict between the demands of stable deterrence and warfighting. Mobile ICBMs are less vulnerable than other missiles. They could ride out a nuclear attack and they reduce the temptation to strike first. So, it is argued, they contribute to stable deterrence. On the other hand STRATCOM, as the warfighter, was asked to look at ways of effectively targeting and destroying these missiles.

STRATCOM were concerned that a new Joint Operating Concept for Major Combat Operations made no reference to nuclear weapons. In a comment on the draft concept they argued – "Should potential adversaries believe the United States only views its nuclear arsenal as a deterrent, and not an available means of waging war if necessary, deterrence will inadvertently be undermined."[56]

A report on Future Roles for US Nuclear Forces criticised the tendency to use "deterrence" to describe all nuclear roles. Its authors argued that the term should be used only for threats of retaliation and should be distinguished from nuclear warfighting.[57] Several significant reports, including the US Doctrine for Joint Nuclear Operation, describe how deterrence might not work against opponents who don't respond rationally.[58] Douglas Feith, Undersecretary of Defense for Policy, told the Senate Armed Services Committee "the United States will need options to defend itself, its allies and friends against attacks that cannot be deterred."[59] The US is preparing to use nuclear weapons in this context, out-with the deterrence model. Yet there is a reluctance to acknowledge that this is a distinct category of nuclear strategy.

Prior to 1991 it was assumed that a force designed for an attack on Russia, could also deal with anything else - "Handle the Soviet Union and you can deter all other potential threats."[60] The NPR departs from this approach. The types of targets that might be attacked if US nuclear weapons were used against a "wider threat" are not different from those that might be attacked in Russia.[61] The difference between Russian and "wider threat" planning is not in the type of targets, but in the emphasis placed on collateral damage and fallout. An attack on Russia would cause colossal devastation. Having weapons that produced fewer side effects is not considered a major issue.[62] However this is a crucial factor in "wider threat" operations. In this case, a threat to use weapons which would result in extensive fallout and damage over a wide area is described as "self-deterring". In addition to the long-term effect on the environment and civilian casualties, fallout does not recognise international boundaries. Neighbouring countries, including allies, could be affected. These concerns have led to a call, in the NPR, to produce nuclear weapons with fewer side effects, which would be more "useable".

Currently most US weapons for use against bunkers and silos have high yields of between 100 and 400 kilotons. The B83 bomb, with a yield of 1 megaton, is retained for use against the most difficult targets. A major concern of the US nuclear establishment is to be able to destroy the same targets but with lower yield weapons, which results in less fallout.

In order to reduce the yield of the weapon, and still destroy a bunker or missile silo, the weapon has to be modified in one of two ways. The first is to increase the accuracy of the bomb, missile or Re-entry Vehicle (RV). Research into developing Manoeuvrable RVs (MARVs) for Trident has been carried out and in the long term this could result in more accurate RVs for Trident missiles and ICBMs. The second way to lower the yield is to use an Earth Penetrating Warhead which detonates when it is below the surface. The 9 megaton B53 bomb has been replaced by the 400 kiloton B61-11 Earth Penetrating Warhead.

Initial studies were started for a Robust Nuclear Earth Penetrator (RNEP). Two design options were proposed. Los Alamos was working on a variant of the B61 bomb and Lawrence Livermore were developing a design based on the B83. Congress withdrew all funding for RNEP during consideration of the FY2005 budget. In February 2005 the Administration attempted to revive the project.[63] Finally, in October 2005, RNEP was withdrawn from the proposed budget for FY2006.

There are fundamental flaws in the quest for new, lower-yield bunker busters. By lowering the yield it is possible to reduce the amount of fallout and collateral damage, but not to eliminate it. The side effects of these weapons remain an insurmountable problem.[64] A threat to use any nuclear weapon for Counter Proliferation is always going to be "self-deterring" and so scarcely credible.

There are publicly available illustrations showing the effect of earth-penetrating nuclear weapons of various yields.[65] A country that was a potential target could be expected to respond by simply digging deeper bunkers. US plans to design sophisticated nuclear weapons can be effectively countered by burrowing further underground with simple technology. Even megaton-yield bombs cannot destroy some targets, such as the deep bunkers in mountains in Russia.[66]

There have been proposals to develop "mini" nuclear weapons in two ways. One is to design nuclear weapons with very low yields. This has been made possibly by the removal of a restriction on developing such weapons. The second factor is to design nuclear warheads that are physically smaller. There has been a call to design a warhead, which would fit within the space constraints of the Guided Bomb Unit (GBU) laser-guided bomb.[67] There also proposals to design weapons with specific effects, such as enhanced radiation.[68] The idea that the latter could be effectively used to neutralise chemical or biological weapons is suspect.

"Advanced Concepts" was a proposal in the FY2004 budget to carry out studies into very low yield and enhanced radiation weapons. The amount allocated was 0.1 % of the nuclear weapons budget. Congress reduced funding for this in FY2004. The following year they withdrew all funding. The Administration did not attempt to reintroduce this project in the FY2006 budget. In FY2005 the funds allocated to Advanced Concepts were redirected to a new programme, the "Reliable Replacement Warhead".[69] The stated aim of this project is to develop warheads or components with similar capabilities to existing warheads.

A report into the Future Roles of US Nuclear Forces argues that the way forward is to design more accurate conventional weapons rather than small nuclear weapons – "The real issue is whether trying to recast a nuclear 'sledgehammer' for use in roles requiring a stiletto is worth the trouble, particularly when conventional 'stilettos' are getting sharper all the time."[70]

A report by Lieutenant Commander Torcolini (US Navy) for Newport Naval War College questions the feasibility of any limited use of nuclear weapons.[71] Torcolini quotes the US Doctrine for Joint Operations, which says, "The outcome of military operations should not conflict with the long-term solution to the crisis".[72] He argues that it is inconceivable that the use of a nuclear weapon could comply with this. There would be a negative reaction from allies and other nations around the world and political repercussions at home. In addition any use of a nuclear weapon would have a significant impact on the attitude of the population of the target nation. The immediate damage from the bomb would be complemented by radiation problems around Ground Zero and also extensive long-term contamination of food production downwind. These would undermine plans for reconstruction.[73]

Pre-emption

In September 2002 President Bush issued a new National Security Strategy. This stressed that America would act first - "America will act against such emerging threats before they are fully formed".[74] This did not just mean that if someone was about to launch a missile, the missile should be destroyed. It meant that if someone was considering a project to build WMD they could be attacked.

The US Air Force Nuclear Doctrine (1998) played down the significance of pre-emption in US nuclear strategy.[75] However the Doctrine for Joint Nuclear Operations (2005) says that any adversary should know that the US "has the ability and will to preempt or retaliate promptly".[76] One of the reviewers of the latter publication suggested that a discussion on pre-emption should be added because this was part of American strategy. The editor replied that such an addition would be inappropriate for an unclassified document.[77] The Universal Joint Target List also includes, as a measure of Strategic Targeting Policy, the "probability of success for pre-emptive attacks on minor nuclear powers".[78] The growing openness about pre-emption comes from Counter Proliferation policy, however the term is applied to all aspects of nuclear strategy. It is likely to be interpreted in Russia and China as including attacks on themselves.

Strategic and Theatre Nuclear Operations

NATO and Britain use the term Sub-Strategic Nuclear Forces. The US military has described the same weapons as Non-Strategic Nuclear Forces. Distinguishing types of nuclear weapons is problematic.[79] Paul Robinson has said, "any use of nuclear weapons is, and always will be strategic. Thus, I would propose we ban the term 'nonstrategic nuclear weapons' as a non sequitur".[80]

There is little reference to the distinction between Strategic and Non-Strategic Forces in the March 2005 version of the Doctrine for Joint Nuclear Operations.[81] There remains a difference when it comes to nuclear operations. There are two types: strategic and theatre. Strategic operations are coordinated by STRATCOM whereas Theatre operations are controlled by the geographical commander. In the early 1990s nuclear options within plans drafted by a regional commander were described as Non SIOP Options.[82] These are now called Theatre Nuclear Options (TNO).[83] TNOs in an Operation Plan can allocate targets to both Non Strategic and Strategic Nuclear Forces.[84] In the latter case the TNO should include an assessment of the impact on the SIOP (OPLAN 8044).

STRATCOM plays a major role in planning both strategic and theatre nuclear operations. During the drafting of the Doctrine for Joint Nuclear Operation, 2005, the roles of the Commander of STRATCOM and the geographic commander were amended. One criticism of the early draft doctrine was that it was primarily concerned with strategic operations.[85] There is an expanded section on Theatre operations in the March 2005 version.

The Universal Joint Task List (UJTL) uses the term "National Strategic Firepower" which includes attacks on targets of strategic value.[86] The US Navy's equivalent document has a different definition - "strategic firepower refers to any type of attack on targets of strategic value, to include nuclear and conventional, both lethal and nonlethal and drug trafficking targets".[87] The SIOP, non-strategic nuclear plans and anti-satellite plans are then listed as examples. The implication is that Trident could be used against drug dealers. This is an example of how blurring the distinction between nuclear and conventional forces creates confusion.

The UJTL refers to "Theater Strategic Targets" which are "targets that have a major and possibly decisive impact on achieving strategic objectives", such as WMD sites. UJTL says that these targets "include, but are not limited to, those found on nonstrategic nuclear strike plans".[88]

It is tempting to distinguish between pre-prepared plans to attack Russia with strategic weapons, on the one hand, and adaptively planned missions involving non-strategic weapons for Counter Proliferation, on the other. However this would be an oversimplification. Adaptive planning can be used to retarget weapons in a strategic nuclear exchange. Pre-prepared plans are drawn up for the use of Non-Strategic Nuclear Forces. The only scenario in which the large number of Non-Strategic Weapons deployed in Europe could be used would be a conflict with Russia. US Strategic weapons could be used in a Counter Proliferation attack.

Countervalue targeting

The main focus of US nuclear strategy is on counterforce targeting. Repeated reference is made to attacking WMD facilities, such as nuclear missile silos and their command and control facilities. The US Air Force Nuclear Doctrine (1998) also referred to countervalue targeting of cities, industries and economic resources.[89] It named harbours, industrial centres and pipelines as examples of possible targets. The 2003 draft of the Doctrine for Joint Nuclear Operations also mentioned countervalue targeting. A representative of STRATCOM pointed out that many operational-law attorneys did not believe that countervalue targeting was lawful because it did not distinguish between civil and military activities. He noted that Al Quaeda's attack on New York in September 2001 could be justified under countervalue philosophy.[90] The March 2005 version of the Doctrine refers to "critical war-making and war-supporting assets" and to holding at risk what the adversary values.[91] Although the word "countervalue" has been excised from the text, the concept remains.

The Universal Joint Task List reveals that targets for National Strategic Firepower include "economic or political centers of gravity".[92] Stephen Younger, Deputy Director of Los Alamos, said that there was an implicit threat to attack cities and that this was "a potent element of the deterrent calculus".[93]

The Nuclear Supplement of the Joint Strategic Capabilities Plan (JSCP-N) lists constraints on nuclear targeting. Most of this section is Top Secret. One declassified paragraph says, "certain target categories are prohibited from attack in specific options".[94] This may include restraints on attacking leadership targets in the initial stage of an attack on Russia. JSCP-N probably also limits countervalue and countercity targeting. However the constraints may be relative and may only apply to some situations. The Chairman of the Joint Chiefs of Staff can approve deviation from the limitations. Regional nuclear plans can include targets that do not comply with the JSCP-N limits. If they do not comply with these constraints this should be noted in the analysis of the Theatre Nuclear Option.[95]

Nuclear attacks on conventional forces

A central feature of Cold War planning was that nuclear weapons could be used to stop an attack with conventional forces. Today US nuclear forces are expected to act as a hedge against the emergence of a substantial conventional threat.[96] This implies that this role might be undertaken by reserve nuclear forces if they were reactivated. Nuclear attacks on conventional forces are also included as a category of potential Theatre nuclear operations.[97]

While this role has not been eliminated, it is no longer a major part of nuclear planning. In the build up to the 1991 Gulf War, Dick Cheney instructed Colin Powell to develop options for the use of nuclear weapons against Iraq. Powell later said that these studies showed, "To do serious damage to just one armoured division dispersed in the desert would require a considerable number of small tactical nuclear weapons … If I had had any doubts before about the practicality of nukes in the field of battle, this report clinched them."[98] The report on Future Roles of US Nuclear Forces describes a similar study.[99] It concludes that air-launched conventional weapons could be almost as effective as nuclear weapons in stopping an armoured division. The conventional option would be clearly preferred because it would avoid the devastation and contamination of an attack with a significant number of nuclear weapons.

Institutional factors

In the US those who stand to gain the budgets and the contracts are significant players in the nuclear weapons establishment. The history of the US nuclear weapons programme illustrates that pressures from the services and from industry are major factors. Rivalry between the nuclear weapons laboratories has been intense. When a new role for nuclear weapons is spotted, the different factions are quick to develop projects to persuade Government that their weapon can carry out the new task. The argument that Trident missiles can be used for limited nuclear attacks appears to be a case of the US Navy trying to take on a task that would otherwise be carried out by the Air Force. In Britain Sub-Strategic Trident emerged as the result of the Royal Navy successfully arguing that they could take on a role previously carried out by the RAF.

Notes

1. Baker Spring, Nuclear Posture Review and Extended Deterrence, p 2

2. C Paul Robinson, A White Paper: Pursuing a New Nuclear Weapons Policy for the 21st Century, SNL, 22 March 2001, p2

3. Nuclear Posture Review, 31 December 2001, www.globalsecurity.org

4. Robinson White Paper

5. Experts warn of accidental US Russian missile launches; report on the NPRI conference in January 2004, www.nti.org/d_newswire/issues/2004_1_28.html#C80DE2E1

6. Robinson White Paper p7

7. G C Buchan, Future Roles of US Nuclear Forces, RAND, 2003, p 2-10.

8. Stephen Younger, Nuclear Weapons in the 21st Century, Deputy Director, Los Alamos, 200.

9. Robinson White Paper

10. Nuclear Posture Review 2001

11. Robinson White Paper, p7

12. Nuclear Posture Review, 2001

13. Younger op cit, p 2

14. There is a substantial difference in early-warning capabilities. Russian satellites do not provide round the clock cover of US ICBM launch areas and cannot cover Trident patrol areas. The second line of defence, from early-warning radars, is also patchy. US satellite and early-warning radar coverage is far more substantial.

15. MG McKinzie et al, The US Nuclear War Plan, A Time for Change, NRDC, 2001

16. The draft of the Doctrine for Joint Nuclear Operations noted that reactivating the reserves would be in breach of the Moscow Agreement. This point was then deleted. Doctrine for Joint Nuclear Operations JP 3-12, 15 March 2005, p2-12f

17. Gen Lee Butler, USSTRATCOM, statement before the Senate Armed Services Committee, 22 April 1993, p3l quoted in H Kristensen, The Proliferation of WMD and US Nuclear Strategy, BASIC, 1998, p 11

18. Robinson White Paper

19. The origins of US Counter Proliferation policy, www.au.af.mil/au/awc/awcgate/xon/definition.htm

20. Hans Kristensen Nuclear Futures: The Proliferation of WMD and US Nuclear Strategy, BASIC, 1998, p14

21. Doctrine for Joint Theatre Nuclear Operations 1996

22. The terminology used changed in the redrafting of the document. WMD was initially used, then replaced by Chemical, Biological, Radiological and Nuclear (CBRN), which was superseded by CBRN Explosive (CBRNE), and then the term WMD was restored. Doctrine for Joint Nuclear Operations, JP 3-12, Final Coordination, 3 Sep 2003.

23. ibid p GL-6.

24. ibid; STRATCOM considered it important to be able to model this exoatmospheric threat, Warfighters M&S Assessment, Modeling and Simulation Analyis Center, 30 September 2000.

25. Doctrine for Joint Nuclear Operations, JP 3-12, Final Coordination (2) 15 March 2005. p 3.1

26. Essentials of Post War Deterrence, p7; Also "Maintaining US ambiguity about when it would use nuclear weapons helps create doubt in the minds of potential adversaries", Joint Doctrine on Nuclear Operations, JP3-12, Final Coordination (2), 15 March 2005

27. ibid

28. ibid p 6

29. Nuclear Posture Review, 2001

30. Essentials of Post War Deterrence, p 7

31. Kristensen Proliferation of WMD, p 10.

32. ibid

33. ibid, p17

34. ibid

35. Universal Joint Task List, Joint Chiefs of Staff, 1 July 2002, CJCSM 3500.04C Task SN 2.4.1.2

36. Kristensen Proliferation of WMD, p14

37. Global terrorism, Islamic terrorists with WMD, is one of the scenarios, which could face the US in 2015. C Poppe et al, Whither Deterrence, LLNL 2002.

38. The National Security Strategy of the United States of America, September 2002

39. Doctrine for Joint Nuclear Operations, JP 3-12, Final Coordination (2), 15 March 2005

40. US budget February 2004, 060271BR, Nuclear Operations

41. "The mission of USSTRATCOM is to establish and provide full-spectrum global strike, coordinated space and information capabilities to meet both deterrent and decisive national security objectives, …" SWPS budget item PE0101313F, February 2004.

42. W Arkin, Not just a last resort, Washington Post, 15 May 2005

43. Both the B61-7 and B61-11 are classed as strategic weapons. The B-2 is the only aircraft certified to carry the B61-11.

44. Repairing damage to the stealth coating takes time and this restricts the number of B2s available for action. Air Force Association Magazine November 2004,

45. There are 8 B61-8 Type 3E trainers and 5 B61-11 Type 3E trainers allocated to the base, which could be used to fully load one aircraft with either version using the sophisticated dummy bombs.

46. The lowest yield of the B61-7 may be 0.3 kiloton, the same as the B61-3, B61-4 and B61-10.

47. B-2 nuclear certified crews are qualified in nuclear command and control procedures every 45 days and briefed on the SIOP every 90 days. B-2 aircrew training, Air Force Instruction 11-2B-2 Volume 1, 19 December 2001.

48. For an attack on Russia the B2s would be armed with full complements of B61-7, B61-11 and B83 bombs. The plan is probably for them to fly over the Artic and bomb a number of targets on a North-South flight-path. The complete stockpile of around 50 B61-11 bombs could be carried by 10 B2s. The remaining aircraft could carry up to 152 B61-7 bombs. Some megaton yield B83-0 bombs are also probably stored at Whiteman AFB for use by the B2s.

49. Nuclear Posture Review, 2001

50. Future Global Nuclear Threats, SAIC report for the DTRA, June 2001, A-6

51. Universal Joint Task List, Joint Chiefs of Staff, 1 July 2002, CJCSM 3500.04C Task SN 3.2.5

52. Buchan op cit

53. Capabilities-Based Approach – Implications for STRATCOM

54. Post START II Arms Reductions Warfighter's Assessment", STRATCOM, 30 December 1996

55. Strategic Advisory Group Policy Subcommittee Meeting 11 January 1996, partially declassified and obtained under the FOIA by H Kristensen.

56. Consolidated Comment Resolution Matrix, Major Combat Operations Joint Operating Concept

57. Buchan op cit

58. Doctrine for Joint Nuclear Operations, JP 3-12, Final Coordination (2) , 15 March 2005.

59. Butcher What wrongs our arms may do, the role of nuclear weapons in counterproliferation, Physicians for Social Responsibility, August 2003 p 50.

60. STRATCOM Phoenix study, partly declassified FOI requested by H Kristensen.

61. Younger op cit

62. Although there has been a shift away from megaton yield weapons since the early part of the Cold War

63. The Administration's proposal for FY2005 included funding RNEP over several years. The revived proposal for FY2006 is for one years funding. FY2006 DOE budget, nuclear weapons, directed stockpile work, p82

64. Dreaming of clean nukes, Michael A Levi, Nature, 29 April 2004

65. Buchan op cit

66. Younger op cit

67. Buchan Future Roles, p62

68. Poppe Whither Deterrence

69. FY2006 DOE budget, nuclear weapons, directed stockpile work, p82

70. Buchan op cit p105

71. Lt Cdr KM Torcolini USN, Theater Nuclear Weapons – Are they really an option for an operational commander? US Naval War College, Newport, Rhode Island, March 1997

72. Doctrine for Joint Operations JP 3-0, quoted in Torcolini op cit.

73. Torcolini op cit

74. The National Security Strategy of the United States of America, September 2002

75. “If nuclear weapons are going to be employed only in response to an attack, rather than in a pre-emptive strike ….” US strategy should be either launch-on-attack or launch-on-warning. USAF Nuclear Operations, AFDD 2-1.5, 15 July 1998

76. Doctrine for Joint Nuclear Operations, JP 3-12, Final Coordination (2), 15 March 2005, p 1-6.

77. Joint Staff Input to Doctrine for Joint Nuclear Operations, 28 March 2003.

78. Universal Joint Task List, Joint Chiefs of Staff, 1 July 2002, CJCSM 3500.04C Task SN 3.2.5

79. Andreas Gabbitas, Non-Strategic Nuclear Weapons: Problems of Definition, in JA Larsen & KJ Klingenbert (eds), Controlling Non-Strategic Nuclear Forces

80. Robinson White Paper.

81. Non-Strategic Nuclear Forces are still defined as “nuclear-capable forces located in an operational area”. Warheads on SLBM and ICBM, plus nuclear armaments at the bases of heavy bombers, are called Operationally Deployed Strategic Nuclear Warheads, Doctrine for Joint Nuclear Operations, Final Coordination (2), 15 March 2005, p GL 5. The 1996 version of the JSCP-N distinguished between Strategic and Non-Strategic Nuclear Forces on the basis of range. Nuclear Supplement to Joint Strategic Capabilities Plan for FY 1996, CJSCI 3110.04, obtained under the FOIA by H Kristensen.

82. Planning Formats and Guidance, USAF Manual 10-401, Vol 2, 1 May 1998.

83. Joint Operation Planning and Execution System Vol 2 Planning Formats and Guidance, CJCSM 3122.03A, 31 December 1999

84. Planning Formats and Guidance, USAF Manual 10-401, Vol 2, 1 May 1998 and the Doctrine for Joint Nuclear Operations, JP 3-12.

85. For example J7 commented – “There is a disconnect between the title of this paragraph “Planning and Targeting” and its contents. The paragraph appears to supply planning and targeting information only for strategic nuclear operations. Where is the corresponding guidance for nonstrategic or theater nuclear planning and targeting ?” Another reviewer commented that the chapter on Theater Nuclear Operations “inadequately addresses the role of nuclear weapons within theater operations”; Joint Staff Input to Doctrine for Joint Nuclear Operations, 28 Mar 2003.

86. Universal Joint Task List, Joint Chiefs of Staff, 1 July 2002, task SN 3.2

87. Universal Navy Task List, 1 May 2001, Task SN 3.2

88. Universal Joint Task List, Joint Chiefs of Staff, 1 July 2002, task ST 3.1

89. US Air Force Nuclear Operations, AFDD 2-1.5, 15 July 1998;

90. It was proposed that “countervalue” should be replaced with “critical infrastructure”, which included “industries, resources and institutions”. Joint Staff Input to Doctrine for Joint Nuclear Operations, JP3-12, 28 March 2003 EUCOM objected to this new term.

91. JP3-12 Comment Matrix Combined Sorted 21 December 2004

92. Universal Joint Task List 1 July 2002 Task SN 3.3

93. Younger op cit

94. JSCP-N, CJCSI 3110.04 12 February 1996, partially declassified and released under the FOI by H Kristensen.

95. "Planners must flag those installations or DGZs included in the options that exceed the limitations of JSCP, Annex C", Planning formats and guidance, USAF Manual 10-401 Vol 2, 1 May 1998

96. Doctrine for Joint Nuclear Operations, JP3-12, Comment Matrix Combined Sorted 2005, 21 December 2004, p6

97. ibid

98. Colin Powel, with Joseph E Persico, My American Journey, New York Random House Inc 1995, p 486, quoted in H M Kristensen, US Nuclear Weapons in Europe, NRDC, 2005.

99. Buchan op cit; In this scenario it is implied that one low-yield nuclear bomb would be used against each company-sized unit. This would mean that 20 – 30 bombs would be used against a division.

Annex B
NATO Nuclear Policy

The traditional role of sub-strategic nuclear forces

In the 1970s the NATO Nuclear Planning Group referred to "theatre" nuclear forces. Royal Navy Polaris submarines were part of these forces.[1] In 1982 NATO changed the terminology to "intermediate-range" and "short-range" nuclear forces.[2] Since 1990 these have been called "sub-strategic nuclear forces".[3]

Today there are two types of sub-strategic nuclear weapons assigned to NATO. The first are US nuclear bombs which are based in Europe and can be used by aircraft from the US Air Force and four other allied Air Forces. The second are Trident missiles on British submarines which have been configured for a sub-strategic role. NATO statements refer to a "small number" of Trident nuclear warheads.[4]

At the heart of the old NATO nuclear plan was the desire to demonstrate that an attack by Warsaw Pact conventional forces would result in a strategic nuclear exchange between the US and the Soviet Union. Tactical nuclear weapons were introduced to make this threat more credible. However the European and US members of NATO held different views on the place of these weapons. The Europeans were wary of a nuclear battle that was confined to Europe. For example, the former West German General Johannes Steinhoff said that he was not opposed to the strategic use of nuclear weapons but added– "I am firmly opposed to their use on our soil".[5] On the other hand, while it suited the US to threaten a strategic nuclear response, it would not have been in their interest to carry out the threat. Henry Kissinger warned that the Europeans should not keep asking for strategic assurances that they could not give, or if they did give, could not execute.[6] Reconciling these differences produced some "tortured and Byzantine logic" in NATO nuclear strategy.[7]

The role of theatre, or sub-strategic, weapons was described by the NATO Nuclear Planning Group in 1981 - "Theatre nuclear forces in NATO Europe provide the crucial link between the conventional defence of NATO Europe and the United States' strategic nuclear forces, the ultimate guarantee of Western security."[8]

The idea that these weapons are a bridge between conventional and strategic nuclear weapons remains the focus of NATO nuclear policy, despite the disappearance of the Soviet threat. The 1991 NATO Strategic Concept said that sub-strategic forces based in Europe would "provide an essential link with strategic nuclear forces, reinforcing the trans-Atlantic link".[9] This phrase was repeated in the 1999 Strategic Concept.[10]

NATO statements also say that "nuclear forces based in Europe and committed to NATO provide an essential political and military link between the European and North American members of the Alliance."[11] The nuclear element of the US forces in Europe is seen as vital – "The presence of United States conventional and nuclear forces in Europe remains vital to the security of Europe, which is inseperably linked to that of North America."[12]

The alliance recognises that the use of nuclear weapons is less likely than during the Cold War. The 1991 Strategic Concept said that, because of the changes in Europe, "the circumstances in which any use of nuclear weapons might have to be contemplated by them are therefore even more remote".[13] The 1999 Strategic Concept refers to this as "extremely remote".[14]

The extension of NATO's nuclear policy to cover former Warsaw Pact countries has concerned Russia. The alliance's involvement in military operations in Kosovo and Afghanistan has also been seen as a threat. While Russia participates on the fringes of NATO, some Russian commentators were disappointed that President Yeltsin's move to have the country fully involved in the Alliance was rejected.[15]

Proliferation

In 1994 NATO's Nuclear Planning Group stressed the role of diplomancy in preventing proliferation, but added that the alliance should "address the range of capabilities needed to discourage Weapons of Mass Destruction."[16] In 1999 the group said – "We reaffirmed our belief that Alliance forces deter the use of weapons of mass destruction, thus contributing to the Alliances goal of preventing the proliferation of these weapons and their delivery means."[17] The term "Alliance forces" is capable of broad interpretation and could include nuclear forces. There appears to be similar ambiguity in the military guidelines, MC400/2, agreed in May 2000. It was reported that these refered to "an appropriate mix of forces" to counter any WMD threat.[18]

The US Nuclear Posture Review of December 2001 placed more emphasis on dealing with new and potential WMD threats by both nuclear and conventional forces. The NATO Nuclear Planning Group was briefed on the Review in 2002. The US National Security Strategy issued in 2002 said that both the forces of the US "and those of our allies" should be equipped "to ensure that we can prevail in any conflict with WMD-armed adversaries".[19] Canada, and most of the European members of NATO, will not openly support plans to use nuclear weapons against an enemy armed with chemical or biological weapons, or seeking to acquire those weapons. The US wants NATO to be ready to use nuclear weapons agains this new enemy, but most other members of the Alliance are cautious.

In 2003 Canadian diplomats made it clear that the NATO 1999 Strategic Concept had not been changed. The Canadians said that NATO policy was that nuclear weapons should not be used against any non-nuclear-weapons state which was a party to the NPT.[20]

A NATO crisis management exercise in 2002 showed divisions within the alliance. The scenario of the exercise was that Iraq was preparing to use WMD against Turkey. The US and Turkey wanted NATO to order a pre-emptive strike. Germany, France and Spain opposed this and wanted to continue with diplomatic moves. Because of these divisions NATO Secretary George Robertson closed the exercise early.[21] This war game was played out while the US made real preparations for the invasion of Iraq.

Despite European hesitation about allocating a counter-proliferation role to NATO nuclear forces, the US has initiated studies into this area. The US has its own command which includes Europe, EUCOM. The US has issued contracts for research to support both EUCOM and NATO. In 1998 a contract was sought for the "European Theater Nuclear Forces Improvement Program".[22] This was for research and development technical support to improve the effectiveness of theatre nuclear forces "supporting the deterrence of Weapons of Mass Destruction." In October 2003 the US sought a further contract for the "European Theater Weapons of Mass Destruction / Nuclear Forces Improvement Program".[23] This was to provide advice to both EUCOM and NATO and the areas to be covered included counterforce options for dealing with WMD, counterproliferation, and the operational effectiveness of theater nuclear forces. This study would focus on improving the potential to use US nuclear forces in a counter WMD role. Recent US budgets also refer to the European Theater Nuclear Support Program. This provides support on nuclear and WMD issues for EUCOM and NATO. The description of this program was modified in the FY 2005 budget with the addition of the phrase "and towards the war on terrorism".[24]

NATO has moved outwith its traditional geographical remit. Following its experience in Kosovo it has taken on a major role in Afghanistan. NATO's Nuclear Planning Group has commented on the danger of North

Korea's nuclear ambitions. But the US has had great difficulty persuading its allies that NATO should play a role in Iraq.

The European Union has adopted its own policy on how to deal with the proliferation of WMD.[25] This places a clear emphas is on diplomatic rather than military means. There is provision for "coercive measures under Chapter 7 of the UN Charter and international law" and these include the use of force. The UN Security Council should play a central role. The policy also says that there should be cooperation with the United States.

The relevance of NATO nuclear weapons is considered further in Annex K Dual Capable Aircraft.

Notes

1. Field Marshall Lord Carver has written of his involvement in the decision to update Polaris with the Chevaline system. He said that Polaris should have become entirely part of the theatre nuclear forces of SACEUR.

2. NATO Nuclear Planning Group March 1982

3. NATO Nuclear Planning Group May 1990, and NATO London Declaration 1990.

4. The Alliance's Strategic Concept, NATO, 24 April 1999

5. Canberra Commission on the Elimination of Nuclear Weapons p10.

6. Ibid.

7. Buchan op cit p25.

8. NATO Nuclear Planning Group October 1981

9. The Alliance's Strategic Concept, NATO, 8 November 1991

10. The Alliance's Strategic Concept, NATO, 24 April 1999

11. Alliance Strategic Concept 8 November 1991 and 24 April 1999 and most recently NATO Nuclear Planning Group December 2003.

12. The Alliance's Strategic Concept, NATO, 24 April 1999 para 41

13. The Alliance's Strategic Concept, NATO, 8 November 1991 para 56

14. The Alliance's Strategic Concept, NATO, 24 April 1999 para 64

15. Schell, op cit

16. NATO Nuclear Planning Group December 1994

17. NATO Nuclear Planning Group December 1999

18. Butcher op cit, p53

19. ibid quoting National Security Strategy of the United States, 20 Sept 2002

20. ibid

21. ibid p 55

22. European Theater Nuclear Forces Improvement Program, Commerce Business Daily, 19 Feb 1998

23. European Theater Weapons of Mass Destruction / Nuclear Forces Improvement Program, 27 Oct 2003

24. FY2005 budget 060271BR Defence Wide/Applied Research, Nuclear Operations.

25. EU Strategy against the proliferation of Weapons of Mass Destruction.

Annex C
British Nuclear Planning system

The technical bounds of independence, with regard to nuclear targeting, have been a closely guarded secret. For example, in the House of Lords in 1995 Lord Stoddart of Swindon asked the government minister to confirm that Trident "can be used without the United States's consent and assistance and can be targeted independently of United States' assistance?". Lord Henley replied, "My Lords, like its predecessor, Trident is an independent nuclear deterrent. That means exactly that, I can go no further."[1] Nevertheless there is some information in the public domain on the mechanics of the British nuclear planning system.

Liaison with the US nuclear planning process

In March 1993, during a session on Trident, the Chairman of the House of Commons Defence Committee raised the following point: "I am not quite clear whether it is still the case that the targeting of our Trident fleet, once it is in operation, will be in liaison with Omaha, and whether it is therefore, if you like, pre-set by NATO decision making?"

Rear Admiral Irwin replied, "We have declared the strategic system to NATO and we plan and deconflict our NATO target plans with the targeting centre in Omaha".[2] De-conflicting is the process of comparing and integrating a number of separate plans to use nuclear weapons. It avoids duplication and fratricide. The US coordinates and de-conflicts its own plans to use large numbers of nuclear weapons at STRATCOM headquarters in Omaha, Nebraska.

From 1959 onwards targeting of the V bombers was "progressively integrated" into the US Single Integrated Operational Plan (SIOP).[3] British personnel were stationed in Omaha for this purpose. Each year the US planners create a new version of the SIOP (OPLAN 8044). It is likely that British plans to use Trident in a strategic role, assigned to NATO, have been renewed on the same annual basis.

The senior US officer in Europe, who is also the NATO Commander (SACEUR), created his own nuclear plans and had a significant input into the planning process. British nuclear weapons were allocated targets within SACEUR's plans. Integrating these plans with the SIOP has been a significant feature of US nuclear planning.

The Chairman of the US Joint Chiefs of Staff has issued instructions on how information from the SIOP can be handed to British personnel. This secret document has the title: "Guidance for the sanitation and distribution of SIOP information to SACEUR, United Kingdom Liaison Cell, Director Strategic Weapons System, and United Kingdom Strategic Targeting Center".[4]

SACEUR, in his role as Commander of US European Command, will have access to un-sanitised strategic targeting data. This guidance probably refers to information he might pass on to British personnel at NATO headquarters, and possibly to officers from other NATO countries. The UK Liaison Cell (UKLC) is identified as being at STRATCOM in Omaha. UKLC is the British presence at the US nuclear planning centre. The work of the British staff at UKLC includes liaison with NATO officers. The Director Strategic Weapons Systems (DGSWS), based in Bath, is responsible for technical aspects of the Trident missile system, including fire control and target planning software.[5] The address of the "UK Strategic Targeting Center" is given as Ministry of Defence, London. This is probably an alternative designation for the Nuclear Operations and Targeting Centre (NOTC) described below.[6]

The earliest form of the guidance listing this distribution was issued in May 1995. In the same year NATO substantially lowered the state of alert of Dual Capable Aircraft. The alliance ceased to have standing nuclear plans at some point between 1995 and 1998. The guidance was revised in March 1999, March 2003 and July 2004. Some of these changes may relate to modifications of the planning systems. The latest form of the guidance uses the new term, OPLAN 8044 information, as well as the old term, SIOP information.

A second US document outlines how information on Multiple Independently Targeted Reentry Vehicles (MIRVs) should be classified.[7] It refers to Top Secret SIOP targeting information and outlines two exceptions to normal restrictions, one is for Canadian personnel working at the North American Aerospace Defence headquarters and the other is for British staff.[8] This guidance permits the release of sensitive information to "UK operational personnel assigned to USSTRATCOM". The number of British personnel with access to sensitive information is to be restricted to "those absolutely necessary to carry out the USSTRATCOM mission".[9] This suggests that UKLC plays a central role in the planning and de-conflicting process.

Nuclear Operations and Targeting Centre

Planning for nuclear weapons is within the remit of the Assistant Chief of Defence Staff (Policy) (ACDS (Pol)).[10] The Director Chemical, Biological, Radiological and Nuclear Policy (DCBRN Pol), a Commodore, has specific responsibility. The UK Liaison Officer at Omaha and his deputy are also responsible to ACDS (Pol). A list of naval positions refers to the Officer in Charge of the Nuclear Operations and Targeting Centre (NOTC), a Commander.[11] There is also an Operations Officer at NOTC, a Lieutenant.[12] The location of the NOTC is "MoD, London".

NOTC houses a computer system that produces British nuclear target plans. Until the late 1990s there will have been a system to prepare nuclear attacks from aircraft using WE-177 bombs and another for Polaris. Since the early 1990s there has also been a special system for Trident.

Official statements in 1994 and 2004 refer to the software and hardware of "the UK shore-based target planning system" for Trident, although they do not mention NOTC by name.[13] In 1994 the MoD said the decision that Trident should take on a sub-strategic role would require "minor enhancements" to the hardware and software of this system. In June 2004, in response to a Parliamentary question, the Armed Forces Minister said that the system had not changed significantly since 1993, but that modifications had been made "to update the hardware and operating system in accordance with good industry practice".[14]

In 1993 it was said that the hardware and software changes required for Sub-Strategic Trident would initially cost £1 million, followed by annual support costs of around £150,000 per year for 10 years.[15] The 2004 statement did not mention of software costs. It said that the expenditure on updating hardware for the system was normally around £250,000 per year, but in Financial Year 2001-02 this cost £584,000.[16] This statement did not distinguish increases in expenditure required for Sub-Strategic Trident.

The peak expenditure on hardware for the shore-based computers in 2001-02 may be related to an update of the Fire Control System (FCS) on British Trident submarines. A new FCS, the Mk 98 Mod 5, entered service between September 2002 and February 2003.[17] It makes Trident substantially more flexible. It will allow rapid retargeting for both single missile and multiple attacks. When a similar system was introduced on US submarines there were also changes to shore-based target planning systems at the Naval Surface Warfare Centre in Dahlgren and at STRATCOM in Omaha. In addition to the new software, it is likely that the MoD also procured new software for their target planning system between 2000 and 2003.

Software

In 1988 an Audit Office report said: "...proving the effectiveness of the system for UK purposes is dependent on the production in the UK of software for targeting, modelling and effectiveness assessment."[18] In practice Britain has relied heavily on US support. The three categories mentioned are inter-related. Modelling and simulation of how a missile system operates is fundamental. The models are used to produce target data and test target plans. Test firing missiles verifies if they are accurate.

There is some indigenous British expertise. Hunting Engineering, now known as INSYS, were the design authority for the Penetration Aid Carrier at the heart of Chevaline.[19] They carried out computer modelling of Chevaline trajectories. The verification of these models was conducted with US assistance. The company later studied various aspects of Trident Re-entry Vehicle (RV) performance. This included analysing how heat erosion affects an RV's flight path. This was a particular problem with the Mk4 Trident RV. INSYS have created models of RV behaviour and have worked for the US Missile Defence programme. However INSYS have limited expertise when compared with US contractors.

Trident missiles are test fired from British submarines near Cape Canaveral under US supervision. The results of the first tests, from HMS Vanguard in 1994, were analysed by two American institutions, the Applied Physics Laboratory of John Hopkins University (APL) and Charles Stark Draper Laboratories. APL use their own models of Trident trajectories to analyse data from test flights.[20] With regard to missile tests from HMS Vengeance, APL said that they "evaluated submarine and missile flight data to assess the reliability and accuracy of the weapon system".[21] The evaluation of missile tests has been almost entirely carried out by these US laboratories. British expertise in this area is negligible.

The Audit Office report pointed out that from 1982 to 1988 the MoD had problems recruiting staff who could produce targeting, modelling and effectiveness assessment software.[22] In 1994 Roger Freeman, the Junior Defence Minister, said that this software development work had been completed "using a mix of internal expertise and specialist contractor support".[23] At the time there were suspicions that the MoD had turned to the US for help.

A proposed contract for Trident software support, issued in America in July 2005, confirms this dependence. It says that the contractor will carry out formal qualification testing of a number of models including "United Kingdom (UK) reference/simulation models" and "US/UK targeting models".[24] US practice suggests that these will not just be for evaluation.

The models will be at the heart of the NOTC target planning system. It is likely that overall system at NOTC is based on the SLBM Integrated Planning System (SIPS) used by the US Navy.

The July 2005 contract says, with regard to the Quality Assurance of UK models, that the contractor shall assist in "analysing the software, data and documentation to verify that all US-only items have been removed."[25] This shows that the "UK models" are produced within the US Trident programme. The main difference between US and UK versions of Trident software is that the variant supplied to Britain is missing some components and some data because these are classified "US-Eyes-Only".

At all stages, from the creation of plans in the MoD to the handling of instructions within the missile, the targeting of the British Trident system is dependent on American software. In 2002 a contract was issued in American for Revision 18 to software for the UK SCSI Media Generation System.[26] This system is probably used to format British targeting data onto magnetic tape. Targeting Change Messages sent by radio are compressed and expanded using unique American software. US contractors create the UK variants of the software that processes this data in the Fire Control System on Trident submarines.

In 1993 Rear Admiral Irwin said, in response to a question at the Defence Committee, that British nuclear weapons could, in theory, be targeted at the US command centre in Omaha. Menzies Campbell MP remarked that "it would cause a bit of a riot at Northwood if we did".[27] But does Britain really have this degree of flexibility? The Royal Navy uses American software for target planning, target data processing and for fire control. Does reliance on this software undermine the independence of Britain's nuclear forces?

The models and programmes purchased from the US may have been set to require coordination with the US system. The software could be fixed so that if a plan were produced which had not been de-conflicted and approved by STRATCOM, then the instructions would not work. The arrangements for rapid retargeting of Trident are likely to be particularly dependent on US support and therefore approval.

The fire control software on the submarine is substantial and complex. The US Navy recognised that it could be sabotaged and they asked an IT company, Mountain State Information Systems, to assess its vulnerability. These specialists carried out detailed research and developed a program to detect illicit code.[28] But what if the programmers wanted to officially sabotage it - to modify the British version and constrain how Trident might be used? It would not be unreasonable for US programmers to modify the software so that British missiles could not be fired at targets within the United States. This could be achieved by adding one or two lines to the thousands of lines of computer code. If the target location was within particular geographical bounds then a variable could be changed which would abort any launch command. In a similar way it would be possible to veto attacks on Russia unless authorised by the US.

There is no evidence that the US has crippled the software in any of these ways. However it could be done. Given the general software dependence it is unlikely that there is sufficient expertise in Britain to rigorously check the programmes. The MoD may have considered issues of software dependency in the past. However recent changes to the target planning and FCS software, and the growing integration and centralisation of the US nuclear planning system make the independence of the British system particularly questionable today.

Adaptive planning and networking

The US nuclear planning system has been modified to place more emphasis on adaptive planning and to increase flexibility in the nuclear targeting process. The new FCS and the US shore-based target planning system are both designed to enable rapid retargeting of missiles. It is likely that the British shore-based planning system can also now produce nuclear attack plans in a short timescale.

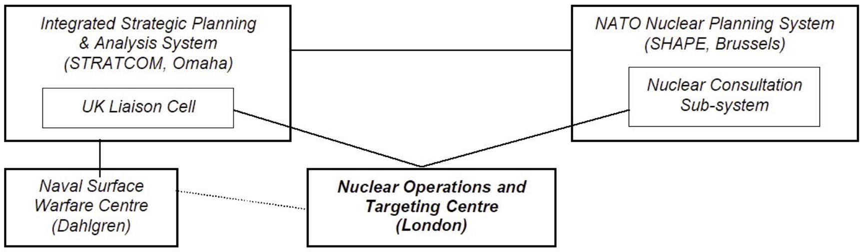
Nuclear planning systems at NATO headquarters and at US Regional Command Headquarters are now integrated into the central system at STRATCOM. It is likely that there has been a similar enhancement of the level of integration between NOTC and STRATCOM to support real-time coordination. UKLC, the British contingent at STRATCOM, is likely to play a role in this.

Co-ordination with NATO

In the past Britain and America have had both nuclear-armed submarines and Dual Capable Aircraft assigned to NATO. It is likely that planning for the two types of weapons was dealt with differently. The US largely delegated planning of nuclear attacks by Dual Capable Aircraft to the geographical commander, whereas most target-planning for Submarine Launched Ballistic Missiles (SLBM) was carried out in the US. It is likely that SACEUR was involved in identifying targets for US and British SLBM, but not in detailed mission planning for their use.

While Britain's Sub-Strategic nuclear force, assigned to NATO comprised Dual Capable Aircraft armed with WE-177 bombs it is likely that SHAPE played a leading role in targeting and mission planning for the force. The decision to replace WE-177 with a small number of single warhead Trident missiles will have caused planning problems. For political reasons it would be desirable to involve several countries in any NATO nuclear attack. This would mean drawing up plans involving both Dual Capable Aircraft from several nations, and British single-warhead Trident missiles. But SHAPE is unlikely to have the expertise to prepare Trident missions. Three parties will be involved in preparing plans for using British Trident missiles in a Sub-Strategic role in a NATO operation: SHAPE, STRATCOM and the NOTC.

Key components of the British nuclear planning process



NATO's Nuclear Planning Group has said that it no longer maintains peacetime plans for Sub-Strategic Nuclear Forces. The alliance does have a system to produce these plans when required. The procedures used in annual ABLE ALLY and ABLE TEAM nuclear planning exercises.

SHAPE has a computer system, the NATO Consultation Subsystem (NCS), which produces power-point presentations illustrating proposed nuclear attacks. This would be used to brief delegates from NATO nations in the nuclear consultation process to approve an attack plan. Plans to use British Sub-strategic Trident would be incorporated into this process.

NCS is a component of the NATO Nuclear Planning System (NNPS). NNPS is used for Sub-Strategic nuclear planning within the alliance. It has been described as a system for planning aircraft missions and so it probably cannot perform detailed mission planning for Trident missiles. However it is possible that the outline of Trident plans can be incorporated. NNPS is integrated into the central US planning system, so this Trident input could come from STRATCOM. Alternatively the British system at NOTC might be able to supply the information to NNPS. There are workstations on the NNPS network at a number of sites across Europe and it is likely that there is one at Northwood and/or at the MoD building in London.

The Naval Surface Warfare Centre Dahlgren Division (NSWCDD) in Virginia develops fire control software for Britain and may to assist in the production and verification of targeting data. Links from the MoD to NSWCDD may either be direct or through STRATCOM.

Security restrictions

In 1962 Britain and the US worked together on nuclear strike plans, dividing targets between them. However neither side was willing to let the other know the yield of the weapons it planned to use against each target. This was four years after there had been a substantial exchange of nuclear weapons' design information. This lack of openness illustrates the extreme sensitivity of nuclear targeting information. The high level of classification given to this material is likely to be a major influence on how British and American nuclear planning is conducted.

Information included in the US nuclear war plan has its own classification, Top Secret Single Integrated Operational Plan – Extremely Sensitive Information (SIOP-ESI). Within this classification the data is divided into categories, each of which is concerned with a specific aspect of nuclear planning.[29] Personnel involved in planning and executing nuclear attacks have access only to information that is essential for their role.

A basic principle of safeguarding the nuclear plan is that only US citizens have access to SIOP-ESI.[30] Handing data to British personnel runs contrary to this principle. The guidance on distributing information to a number of British locations refers to the disclosure of "sanitized" SIOP information. In this context, sanitization is the removal of sensitive material so that a document can be given a lower security classification and distributed more widely.

Lee Butler has revealed how compartmentalisation within the nuclear planning process means that no-one has an overall view of what is actually going on. British staff work on the fringes of this system. They will only be given fragments of information. On the other hand it is likely that the MoD will have to reveal most of Britain's proposals in order to participate in the process.

Friendly nuclear forces in US nuclear plans

The US Air Force manual on Planning Format and Guidance shows the structure of US nuclear attack plans.[31] The manual shows the format of US Air Force Europe (USAFE) Operations Plan (OPLAN) 4123-97 for the Defence of Western Europe in General War. The nuclear attack plan is in

Appendix 1 to Annex C. Within this appendix, under "Situation – Friendly Forces", the nuclear forces of friendly countries would be listed in two sections.

In one section the plan will "State how the nuclear operations of external forces, other than those tasked to support this operation, may affect the nuclear operations of this force". In the context of Western Europe the nuclear forces of France would probably come under this heading. For plans covering the Middle East it is likely that Israel's nuclear forces would be listed.

The other section will "List the specific tasks assigned to friendly forces, not part of this command, for support nuclear operations envisaged herein". In the case of USAFE OPLAN 4123, tasks allocated to German, Belgian, Italian and Dutch nuclear-capable aircraft would probably be listed. It is likely that British nuclear forces would be included in this section and allocated specific tasks.

This guidance is from 1998. It is possible that USAFE OPLAN 4123 is no longer maintained as a current plan. There is a substantial effort to automate the production of similar plans. It is likely that the nuclear forces of friendly countries will be incorporated in the new computerised system in a similar way.

Top Secret data links

The Nuclear Planning System at NATO headquarters requires a special communications link with STRATCOM in order to gain access to Top Secret data. NOTC will require similar access. It is likely that special communications links are in place between the MoD building and Omaha to support nuclear planning.

Until recently Top Secret data was handled only on exclusive computer networks. However in the last few years Multi Level Security systems have been introduced. These are designed so that users on the same network have different levels of access to a central database.[32] Since 1998 the US has deployed the Joint Cross Domain eXchange (JCXD) system.[33] This provides access at various levels including Top Secret Special Compartmented Information and US/UK eyes only. One of the first places outside the US where this system was installed was at Northwood in London. This system was primarily designed for naval intelligence information including sensitive Special Intelligence data, however it might also support nuclear targeting.

Targeting Moscow

In his statement to the Defence Committee in March 1993, Rear Admiral Irwin, after mentioning how British NATO plans were de-conflicted at Omaha, added that "Ministers have always made it plain that we retain the right to use Trident away from that should there ever be an overriding national need."[34] In the case of Chevaline the focus of the independent plan was an attack on the Moscow area. This was also the intention when Trident was developed.

There are particular problems with maintaining an independent capability to plan this type of attack. Crucial to this plan will be calculating how to overcome the Anti Ballistic Missile (ABM) system around the city. The US has a suite of computer programmes, centred on the Multiple Engagement Model, which are used to predict the effect of the Moscow ABM system. Access to these applications would have a significant effect on the viability of Britain's independent attack plan. One aspect of penetrating ABM defences is the hardening of RVs so that they will withstand the effect of an Electro Magnetic Pulse. A special security classification, Atomic Artificer, is given to information on RV hardening that America supplies to Britain.[35]

Authorisation

Britain has procedures to issue instructions to launch a nuclear attack. Michael Clarke describes these as extremely simple and yet impossible to duplicate, imitate or frustrate. These unique procedures are used rather than US or NATO Emergency Action Messages.

The US Navy can use all available communications systems to send emergency action messages to launch Trident missiles. Messages would be sent simultaneously on a number of frequencies. The MoD is likely to have a similar procedure. A briefing on submarine communications in 2001 said that "SSBN operations pre-empt UK communications".[36]

In 1961 a Whitehouse memorandum described how the President should consult with allies before using nuclear weapons: "Reach joint decision with Prime Minister by speaking personally with him before forces equipped with nuclear weapons operate from bases in the U.K. Consult with British before using nuclear weapons anywhere, if possible. Before launching Polaris nuclear weapons, take every possible step to consult with Britain and other allies".[37] It can be expected that there is similar guidance in Whitehall specifying the need to consult with the US before British nuclear weapons are used. This requirement for consultation may be reflected in the British Emergency Action Message system.

Northwood

British Trident submarines are controlled through Command Task Force (CTF) 345 at Northwood in Middlesex.[38] AMS, a subsidiary of British Aerospace, is the lead contractor for a major upgrade of the command and communications facilities at CTF 345. In 2003 they were awarded a five year contract worth 17 million Euros. This covered support, maintenance, post design services and developing a training programme for CTF 345.[39] The work is described as "a turn-key project involving the provision of a bespoke message processing and handling system for controlling radio traffic to submarines".[40] The new communications network, which AMS are producing, is the Submarine Broadcast Processing System. It will operate from the facility to British and NATO submarines.

The United States submarine force has a representative at Northwood.[41] This officer coordinates British and American SSBN operations when they are acting in unison and prevents "mutual interference" when they are acting apart.[42]

Notes

1. House of Lords 11 January 1995.

2. Progress of Trident, 6th report, Defence Select Committee 1993, HC 549 minutes of meeting 10 March 1993, para 1573.

3. Quinlan British Experience

4. CJSCI 3231.04C, 6 July 2004, listed in Compendium of Current CJCSI Directives, 14 January 2005

5. The Audit Office report which highlighted a shortage of staff for targeting software said that this was a problem for DGSWS; Comptroller and Auditor General's 1987 report on the Trident programme.

6. The location of UKSTC is MoD, London. CJSCI 3231.04C, 6 July 2004, listed in Compendium of Current CJCSI Directives, 14 January 2005

7. Security Classification Policy for MIRVs, CJSI 5220.01A, 1 July 2004

8. Mission-related capability (eg range, manoeuvre capability), Effectiveness, Accuracy, Reliability and Penetration aid mission requirements (eg spacing, decoy, chaff deployments) are classified Secret. Information on Survivability/Vulnerability is normally Secret but is Top Secret where revealing the information could defeat the system; Security Classification Policy for MIRVs, CJSI 5220.01A, 1 July 2004.

9. Sensitive information can also be passed to Canadian personnel at North American Aerospace Defence Command (NORAD); Security Classification Policy for MIRVs, CJSI 5220.01A, 1 July 2004. The mission of STRATCOM is full spectrum global strike.

10. This position has previously been called Assistant Chief of Defence Staff (Policy and Nuclear). It is filled by a Rear Admiral, Air Vice Marshall or Major General.

11. RN Common Appointments, Commander; www.rnreference.mod.uk

12. RN Common Appointments, Lieutenant Commander; www.rnreference.mod.uk

13. Defence Committee 2nd report 1993-94, Progress of the Trident Programme, p 26; Reply by Adam Ingram to a question from Angus Robertson, Hansard, 28 June 2004.

14. Reply by Adam Ingram to a question from Angus Robertson, Hansard, 28 June 2004.

15. Progress of the Trident Programme, Defence Committee 2nd Report 1993/94, HC 297 p6 & 26.

16. Reply by Adam Ingram to a question from Angus Robertson, Hansard, 28 June 2004

17. ibid

18. Comptroller and Auditor Generals Report 1987, para3.13, Q64; quoted in the Defence Committee Report on the Progress of Trident, HC 422 1987/88.

19. Declassified report on Chevaline circulated by Alan Thomson and published on ;

20. System-Level Testing in Operational Environments, in John Hopkins APL Technical Digest Vol 17, No 4 (1996)

21. APL update 17 October 2000
22. Comptroller and Auditor General's 1987 report: quoted in the Defence Committee Report on the Progress of Trident, HC 422 1987/88.
23. Letter from Roger Freeman MP to Frank Cook MP 22 August 1994.
24. Advance Notice Dahlgren, Software Engineering, Analysis, Research, Development, Test and Engineering Support – Statement of Work for K Department omnibus, 18 July 2005
25. ibid
26. K-Trident FBM Fire Control Rev 18 to UK Software, 10 May 2001. Sol N00030-98-G-0051-NJ96.
27. Minutes of meeting 10 March 1993, 6th Report of the Defence Committee, The Progress of the Trident Programme, 1992/93, HC 549
28. MSIS Previous Effort,
29. The document that explains Emergency Action Procedures is classified SIOP-ESI category 4 (USCINCSPACE Volume IV authority training and certification, UHOI10-29, USCINCSPACE, 27 December 1995). Aircrew flying nuclear bombers and their supporting tankers have access to category 1 and sometimes also to categories 4 and 10 (Alert planning procedures for Grand Forks AFB). Contractors working on the NPES nuclear alert system were also required to have SIOP-ESI category 1,4 & 10 clearance (Nuclear Planning and Execution System contract). Category 8 data is handled within ICBM command posts (Air Force Command Posts, AFSPC110-210, 1 March 2004).
30. Application of Special Eligibilty and Clearance Requirements in the SIOP-ESI Program for Contractor Employees, DoD I 5220.28, 8 March 1978.
31. Planning Formats and Guidance, USAF Manual 10-401, Vol 2, 1 May 1998
32. Rick Smith, The Challenge of Multilevel Security. www.cryptosmith.com
33. Joint Cross Domain eXhange, Operational System Overview, SpaWar Powerpoint presentation.
34. Progress of Trident, 6th report, Defence Select Committee 1993, HC 549 minutes of meeting 10 March 1993
35. UK-USA classification equivalence table, http://badge.lanl.gov/uk-usa_classification.shtml
36. AD Sutherland, Submarine issues for future networking in the maritime battlespace, AUSCANNZUKUS paper.
37. Checklist of Presidential Actions, Memorandum for McGeorge Bundy, Whitehouse, 28 July 1961.
38. Sutherland op cit
39. BAe Investment Brief November 2003
40. www.mod.uk/dpa/ipt/CSSIS_Project_Info.htm
41. Until June 2003 the officer represented the US Atlantic submarine headquarters in Norfolk, Virginia. He now represents a subordinate command, US Submarine Group (COMSUBGRU) 8, based in Italy. Since 2003 COMSUBGRU 8 has been responsible for American submarines deployed in the North West Atlantic as well as the Mediterranean.
42. USCINCATLANT joint staff instruction, 8 Feb 1985, quoted in RS Norris, AS Burrows & RW Fieldhouse, Nuclear Weapons Databook vol V, p102.

Annex D

US Nuclear Planning system

Former nuclear commander, General Lee Butler, described America's nuclear war plan as millions of lines of unfathomable computer code which were translated into a short slide presentation given to the handful of people with the security clearance to see it.[1] The current nuclear war planning system has over 12 million lines of computer code. The programming effort employs around 500 people.[2]

The software has been in transition for more than a decade and is now being substantially changed again. The system is taking on a wider role. It is being asked not just to produce nuclear war plans, but also to prepare conventional strike options. The distinction between strategic and theatre nuclear weapons has been blurred. Adjustments will be made so that plans can be produced more rapidly. The system is also being asked to produce plans for potential targets around the world.

The main task is producing OPLAN 8044, formerly known as the Single Integrated Operations Plan (SIOP).[3] OPLAN 8044 contains options for pre-planned nuclear war. In the past it was primarily oriented against the Soviet Union. Around 80 % of the targets are in Russia. The proportion of targets in China and elsewhere has increased in recent years.

Creating, analysing and revising OPLAN 8044 is a complex process. These are the tasks for which most of the computer applications in the system were created. A new plan is produced for each year. Until recently it took the planners 24 months to produce each one. This time has been reduced to 6 months.

In December 1992, STRATCOM set up the Strategic Planning Study Group. This group of ten people was to review the nuclear planning system in order to make it more flexible and to move it beyond the confines of Cold War targeting. The study group developed the idea of a "living SIOP".[4] Nuclear war planning was to be extended beyond of the limits of the annually updated plan. The system would be asked to produce targeting plans on demand. The product of this study was the Strategic War Planning System (SWPS). In 2004 SWPS was renamed as the Integrated Strategic Planning and Analysis Network (ISPAN).

ISPAN will have a wider role than its predecessor. While it will remain the process for organising nuclear war, it will also be able to prepares plans for conventional attacks. It will be used to support Global Strike, the ability to attack a target anywhere in the world, as well as Missile Defence, Space Operations and Information Operations. It is also to support the use of emerging non-kinetic weapons. The term non-kinetic includes electronic warfare and psychological operations. The new programs will provide the capability to use either nuclear or conventional weapons in attacks on WMD and related targets.

Adaptive Planning

A distinction is made between "deliberate" planning, which is the construction of detailed target plans in advance, and "adaptive" planning. Adaptive Planning is the driving force behind many of the recent changes to the nuclear planning system. A US Air Force article, published in 1987, describes Adaptive Planning as "rapid and effective planning of a dynamic force against a dynamic target."[5] It argues that - "the more rapidly the crisis unfolds, the greater the need for adaptive mission planning".[6] The article refers to the SAC Adaptive Planning System Master Plan. This plan was to develop in-flight retargeting of nuclear bombers between the late 1980s and 2000. Adaptive Planning in this context refers to making last minute alterations to target plans in order to adjust to changing circumstances.

The early draft of the Doctrine for Joint Nuclear Operations used the term in a similar way. It described how part of the strategic force could be held back as a reserve and allocated new targets at short notice in a later phase of a nuclear exchange.[7] One of those reviewing the doctrine suggested this was too narrow a definition of Adaptive Planning.[8] The Nuclear Supplement to the Joint Strategic Capabilities Plan (JSCP-N), 1996, also indicates that, on the one hand, adaptive planning is the primary means of targeting the secure reserve, and on the other, adaptive planning can be used before, during or after a Major Attack Option, and can involve reserve, SIOP or Non Strategic forces.[9]

An interview with General Lee Butler in 1993, adds a further meaning to the term. He describes how STRATCOM would in future prepare plans, not to deal with a specific geographical group of targets, but a generic target set. A series of options would be created to deal with these generic targets. The options would include nuclear weapons and conventional weapons. If there was a need to respond to a real situation then an appropriate plan would be extracted from the system and modified as required. General Butler said that Adaptive Planning would be used in this way to produce potential responses to WMD threats.[10] An amendment to the Joint Doctrine for Nuclear Operations added the sentence – "plans and options developed during deliberate planning provide a foundation for adaptive and crisis action planning".[11]

The March 2005 version of the Joint Doctrine adds a new concept of Crisis Action Planning. This involves being able to strike targets at very little notice, even where there is no existing plan that can be adapted.[12]

The US Nuclear Posture Review of 2001 called for more flexibility in nuclear planning. It said that Adaptive Planning was needed "to generate war plans quickly in time critical situations."[13] At the time of the Review it was said creating a plan to attack a target with a nuclear weapon took between 12 and 24 hours, depending on the type of weapon. The Review emphasised the need to shorten this. It also said that one of the key areas on which future work was needed was the ability to attack "mobile and relocatable targets".[14] Attacks on these would require near-real-time targeting of nuclear weapons.[15]

Paul Robinson of Sandia National Laboratory has questioned the emphasis being given to Adaptive Planning. He said: "I believe it is essential for us to preplan our targets for any likely contingency. While adaptive planning capabilities will be necessary and important in preparing us to handle events we cannot always predict or know, they just cannot rise to the same level of sophistication as we could achieve in deliberative planning".[16]

New computer programs have been written and existing ones have been modified so that the complex targeting calculations can be carried out more quickly. In future the US will be able to create a new plan for a limited nuclear attack in a few hours. In the past if an American Theatre commander asked for a nuclear strike plan this document would have been prepared manually. Now the process is being automated. In 2002 the new Universal Joint Task List introduced requirements that STRATCOM be able to construct a scenario for nuclear use within hours and also prepare a plan to use one weapon against one target within hours.[17] In addition to re-targeting small numbers of weapons, the new system will be able to carry out large scale retargeting, possibly of the order of re-targeting 1,000 sorties in 24 hours.[18]

In the past, the nuclear planning process consisted of a large number of computer applications which performed their specialist functions in isolation. Their output was then tested in other programs or combined with other data. The recent requirements for Adaptive Planning and rapid retargeting have meant that the components have been more closely integrated. Many applications have been combined in the central Enterprise Database (EDB).

The nuclear planning process has not only been rationalised, but has also been integrated with external systems. NATO's Nuclear Planning System (NNPS) and the equivalent facilities operated by US Theatre commanders have now been networked into the central system.[19] The central nuclear war planning system is taking over the key role in preparing all nuclear weapons missions, including those initiated by US Theatre Commanders. The same is probably also true with regard to NATO nuclear bombing missions.

Integrated Strategic Planning and Analysis Network (ISPAN)

In 1993 work began on an upgrade of the nuclear planning system. At the time this was called the Strategic War Planning System (SWPS). SWPS was described as "a computing environment composed of software, personal computers, workstations, servers and networks used to build and maintain classified national war plans".[20] It entered service between 1998 and 2001. The Nuclear Posture Review of December 2001 initiated a review of SWPS.[21] As a result in March 2003 the Government began to look for contractors who would modernise the system.[22] In 2004 the project was renamed the Integrated Strategic Planning and Analysis Network (ISPAN).[23] In August 2004 Lockheed Martin were awarded a $213 million, 10-year contract to develop ISPAN. The first block or phase, integrating legacy systems, is to be completed by 2007.[24]

Target list

The US maintains a database of over 150,000 potential targets around the world on the Modified Integrated Database (MIDB). On the basis of political guidance and direction from the Joint Chiefs of Staff, a list of key targets for nuclear weapons is extracted from the MIDB. This list is called the National Target Database (NTB). In the late 1990s there were estimated to be are around 2,500 sites in the NTB - 2,000 in Russia, 300 – 400 in China and 100 – 200 elsewhere.[25]

The NTB is a list of installations. From this a slightly shorter list, of aimpoints, is created. Where two or more installations are close together they are combined in one Target Island.[26] A Desired Ground Zero (DGZ) is calculated for each Target Island. The DGZ is the point at which a nuclear weapon should be detonated to destroy the installation(s). The database of these aimpoints is the National DGZ List (NDL). The NDL Integrated Development System Version II (NIDS II) creates this list. NIDS II is the main targeting program in ISPAN. It is produced by SAIC and has 1.2 million lines of computer code. As well as creating the list it provides geographical information and makes an initial allocation of weapon to target.[27] NIDS II is being modified to improve the system's ability to calculate DGZs for the use of a small number of nuclear weapons in support of an operation in a specific Theatre.[28] The Probability of Damage Calculator (PDCALC) estimates the damage caused by a nuclear weapon of a particular type, including the blast effect.[29] It is used within NIDS II and other programs. One of the sources of data used by NIDS II is the United Kingdom Liaison Office (UKLO) at STRATCOM.[30]

Allocation and Quality Review

Allocation involves assessing which type of weapon, ICBM, SLBM, bomber or cruise missile, should be used against which target. Quality Review is the process of testing this to calculate if_each target would be destroyed. This work is carried out by the Automated Window Planning System (AWPS), which is a Windows application.

Nuclear weapons are not allocated on the simple basis of one weapon per target. US nuclear planners uses the term layering. Layering is "the application of two or more weapons to a single target to improve the confidence that a weapon will arrive and/or the desired damage will be achieved."[31] The number of weapons allocated may be more than double the number of aimpoints.[32]

Missiles

The Missile Graphics Planning System (MGPS) is the main missile-planning program. MGPS is a Windows application. It is used to plan attacks using land-based ICBM and submarine-launched Trident missiles and is produced by TRW Data Technologies. A contract to provide ongoing support for MGPS explains that the system is designed to "rapidly allocate and assign intercontinental and sea-launched ballistic missiles".[33] The programme is being upgraded to make it more flexible and so that additional components can be added.[34] MGPS is a package of software components. The diagram indicates the key functions.

ICBM and Trident missiles both carry Multiple Independently-targeted Re-entry Vehicles (MIRVs), each RV contains a nuclear warhead. This means that one missile can hit a number of targets. However the group of targets, which can be hit by one missile, have to all be within a predefined area, called a footprint. The footprint varies with the type of missile, number of RVs and the range.

It is normal in nuclear plans for two or more warheads to be aimed at the same target, particularly in the case of bunkers and missile silos. Blast, dust and fallout from the detonation of the first warhead can affect the second warhead. This may be destroyed, damaged or detonate at the wrong height. This is called “fratricide”. The number of hardened targets destroyed in a nuclear attack could be significantly lower than planned because of fratricide.[35]

The Multiple Engagement Model (MEM) is designed to estimate the effect of the Russian Anti Ballistic Missile (ABM) system around Moscow. It calculates how many US nuclear warheads might be destroyed by the ABM system in a variety of situations. It is used to simulate a range of potential ABM defences and a range of possible US attack options. This includes assessing the effect of penetration aids and decoys.[36]

The SLBM Integrated Planning System (SIPS) prepares plans for Trident missiles. It is produced by the Naval Surface Warfare Centre Dahlgren Division (NSWCDD).[37]

Aircraft and air-launched cruise missiles

The Air Vehicle Planning System (APS) is used to plan missions for both bombers and air-launched cruise missiles. It also plans supporting reconnaissance and tanker missions. APS is the main program for air missions and it has recently been developed by BAe Systems.[38] It is a large computer application with 6.5 million lines of code and a one-terabyte database.[39] The Extended Air Defence Simulation (EADSIM)_is used to analyse the likelihood of bombers penetrating air defences. It is used to support APS and also in conjunction with analysis programs.[40]

Analysis

STRATCOM produces the Red Integrated Strategic Offensive Plan (RISOP). This is their estimate of the Russian nuclear attack plan. It also includes the nuclear weapons China and other potential enemies. Playing out RISOP against OPLAN 8044 in simulations is a major part of the development of the US war plan. The Weapons Assignment Model (WAM) is the main tool used to simulate the RISOP. It is also used to test future OPLAN 8044 options as they are developed.

Theatre Planning

Combatant commanders, such as CINC EUCOM, have their own operation plans. These may include nuclear appendix. The USAF Planning Formats and Guidance manual shows the format of these plans.[41] It uses the outline of USAFE OPLAN 4123-97, Defence of Western Europe in General War, as an example. The nuclear plan is Appendix 1 to Annex C.

Details are given in three tabs to this appendix.

Tab A lists a series of Non SIOP Options (These are now called Theatre Nuclear Options). There can be sub-options within options. For each there is an objective followed by a list of targets. A specific type of weapon is allocated to each target. The same targets may appear in several options. In each case "all targets required to achieve the stated objectives of the options should be included".[42] Options may include mobile as well as fixed targets. Notional DGZs are given for mobile targets.

Tab B lists Nuclear Options Analyses for each of the options in Tab A. The analysis is an estimate of the effect of the nuclear strikes. In addition to assessing military damage there is also provision for describing the effect on production capability when economic targets are attacked. The analysis should include an estimate of fatalities. The probability that the weapon will reach its target is also included. The plan may allocate targets not only to Non Strategic Nuclear Forces, but also to Strategic Nuclear Forces, including Trident. The effect on the SIOP of using Strategic Nuclear Forces should be assessed for each option. Tab C lists the reconnaissance operations needed to support each option.

NATO identified each nuclear target in its plans with a four-digit Allied Command Europe Designated Ground Zero Number (ADN). ADN is one of the headings in the tables in Tab B of the USAFE OPLAN 4123. This shows that many of the details of the NATO nuclear plan were also specified in the United States' own plan.

Although it is possible that the plan outlined above, USAFE OPLAN 4123, has not been sustained, there is today a substantial effort to speed up the production of theatre nuclear attack plans. This is a major priority for STRATCOM. A review of modelling and simulation requirements says - "Strategic attacks on theater targets" is a major simulation focus for STRATCOM.[43]

The Theater Planning Integrated Subsystem (TIPS) is the main instrument for producing these plans.[44] It is due to be completed in FY 2007. It should provide "significant increases in adaptive planning timelines".[45] The programme will automate procedures that were previously carried out manually. TIPS will create plans for nuclear and conventional weapons.[46] While the focus of TIPS will be on preparing air missions, it will also be able to construct plans to attack individual targets with any weapon in the US nuclear arsenal. While strategic nuclear planning includes prioritisation, this is not the case with theatre plans.

The creation of TIPS represents a shift in planning emphasis from the theatre commander to STRATCOM. STRATCOM is described as the "plan manager".[47] While the US Theatre Commander selects the initial targets, STRATCOM is responsible for developing the plan to attack these targets.[48] There may have been a similar refocusing of effort in NATO nuclear planning. It is possible that STRATCOM also now plays a larger role in supporting British efforts, in order to reduce planning timescales.

Secure Reserve Force

A proportion of the Trident submarines on patrol form the Secure Reserve Force (SRF). In the past some strategic bombers have been part of the SRF. This force has been described as follows: "Traditionally, we have held a portion of our most survivable forces in a secure reserve. The secure reserve handles contingencies and gives limited restrike capability".[49] The SRF is generally excluded when calculating what forces are available for a Major Attack Option.

Comments

The US has significantly enhanced the capabilities of its nuclear forces by substantially upgrading the computer systems used to control nuclear war. Tailor-made nuclear plans can now be produced in a few hours. These transformations are an important part of the trend to make nuclear weapons more useable. The manufacture of a new missile would be visible way to make nuclear forces more destructive. Modifying computer hardware and software is invisible, but its effect is no less significant. The application of modern computer power to nuclear target planning is increasing the capability of US nuclear forces. The sophistication of the ISPAN system cannot be matched in Britain. It is likely that this US network plays a significant role in British nuclear planning.

Notes

1. Washington Post Magazine 7 December 1997

2. M Winters & B Wilczynski Data Interoperablity: Foundation of Information Superiority,; www.chips.navy.mil/archives/00_jul/data_interoperability.html

3. The full title of the plan in effect in FY 2003 was Operations Plan 8044 Revision 03, IAW CM-757-03, 8 Feb 03 according to the Joint Staff input to Doctrine for Joint Nuclear Operations (2nd Draft), 28 Feb 03.

4. Kristensen Proliferation of WMD, p11

5. Col D Seares, Adaptive Mission Planning, www.airpower.af.mil/airchronicles/aureview1987seares2.html

6. ibid

7. Joint Staff input to Doctrine of Joint Nuclear Operations (2nd draft), JP3-12, 28 Mar 03.

8. Amendment suggested by J-3. The editor rejected this saying that "The military savvy audience will not come to the conclusion that emerging targets only appear after initial laydown" Joint Staff input to Doctrine of Joint Nuclear Operations (2nd draft), JP3-12, 28 Mar 03.

9. Nuclear Supplement to the Joint Strategic Capabilities Plan for FY 1996 CJCSI 3110.04, partially declassified and obtained under the FOIA by H Kristensen.

10. Kristensen Proliferation of WMD, p11

11. Joint Staff input to Doctrine of Joint Nuclear Operations (2nd draft), JP3-12, 28 Mar 03.

12. Doctrine for Joint Nuclear Operations, Final Coordination (2), JP3-12, 15 March 2005

13. Nuclear Posture Review, 2001.

14. Nuclear Posture Review, 2001; The Universal Joint Task List includes a measure "to construct an adaptive plan against one target" within an undisclosed number of hours. UJTL, 1 July 2002 Task SN 3.2.1

15. A 1979 nuclear planning model suggests that one way of using nuclear weapons against mobile targets was to use a series of nuclear weapons in a fixed pattern to completely devastate a large area. The spacing between each aimpoint would depend on the degree of damage required. This approach might also be used against nuclear submarines at sea. Strat Missiler, A strategic missile (ICBM/SLBM) analysis computing model, USAF, 20 June 1979.

16. Robinson White Paper

17. Universal Joint Task List, Joint Chiefs of Staff, 1 July 2002 CJCSM 3500.04C, task SN 3.2 There is also a requirement to construct a scenario supporting nuclear weapon use within hours listed as a separate measure. Both of these references are under SN 3.2 "Manage National Strategic Firepower". The ability to produce a plan for one weapon on one target within hours is also listed

under ST 3.1 “Process Theater Strategic Targets”.

18. Kristensen Proliferation of WMD, p12

19. RDT&E Project Justification, 060271BR Nuclear Operations, February 2003

20. SWPS Budget Justification Item Feb 2002

21. Nuclear Posture Review, 31 December 2001.
www.globalsecurity.org/wmd/library/policy/dod/npr.htm

22. Statement of Work for SWPS Solicitation F25600-02-R-0037, 13 March 2003, USSTRATCOM.

23. USSTRATCOM Planning System Modernization, Statement of Objectives, Solicitation FA8722-04-R-0003, 22 January 2004.

24. ibid

25. MG McKinzie, the US Nuclear War Plan A Time for Change, NRDC, 2001, p10

26. A Target Island is “a geographical area encompassing one or more installations” - Nuclear Supplement to the Joint Strategic Capabilities Plan for FY 1996 CJCSI 3110.04. One component of ISPAN is the Target Island Construction and Maintenance System (TICAMS).

27. Engineering Services for maintenance and enhancement of NIDSII software, Sources Sought Announcement, USSTRATCOM, FBO Daily 16 July 2003

28. Described as “enhanced Theater support”, Engineering Services for maintenance and enhancement of NIDSII software, Sources Sought Announcement, USSTRATCOM, FBO Daily 16 July 2003; Modifications are to be completed by FY 2007; SWPS budget item, PE 0101313F February 2004.

29. Joint-owned Models and Simulations used by Joint Components, Joint Staff J-8/SAMD, DSN 225-1698, 10 March 1997

30. “NIDS-II .. receives data from the UKLO (SACEUR) database”, The Post Cold War SIOP and Nuclear Warfare Planning, A Glossary, Abbreviations and Acronyms, WM Arkin and H Kristensen, NRDC, January 1999.

31. Nuclear Supplement to the Joint Strategic Capabilities Plan for FY 1996 CJCSI 3110.04

32. One example shows that 20 warheads could be allocated to 8 aimpoints. Pheonix Force Structure Review, STRATCOM 24 August 1991, partially declassified and obtained under the FOIA by Hans Kristensen.

33. Missile Applications Software Support (MASS), Pre-solicitation, FA4600-04-R-0003, 18 April 2004, FBO.

34. ibid; Modifications to MGPS should be completed by FY 2007; SWPS budget item, PE 0101313F February 2004.

35. Paul K Davis, Probabilistic Dependencies in Combat Models, RAND.
www.nap.edu/html/tech_21st/msj.htm

36. Engineering services for MEM, FA4600-04-R-0008, sources sought notice 28 November 2003, Federal Business Opportunities

37. T Gemmill, Current K Department Models and Simulations, NAVSEA Dahlgren, 30 November 1999. SIPS is described in the Section of this report on Trident Targeting and Fire Control.

38. Air Vehicle Planning System, BAe Systems website.

39. Maintenance and enhancements for AVPS, Sources Sought Announcement, 25 July 2001, USSTRATCOM, Federal Business Opportunities.

40. Non-Joint-owned Models and Simulations used by Joint Components, Joint Staff J-8/SAMD, DSN 225-1698, 10 March 1997

41. Planning Formats and Guidance, USAF Manual 10-401 Vol 2, 1 May 1998

42. ibid.

43. Warfighter M&S Assessment, Modeling and Simulation Analysis Center, 30 September 2000.

44. TIPS Technical Direction Document, ISPAN solicitation, 2004; this is similar to the work described as SWPS-AP (Adaptive Planning) in RDT&E Budget Item Justification 0101313F SWPS February 2002.

45. The designation of the documents which TIPS will produce has changed. Until 2003 these were referred to as Theater Planning Support Documents. The FY 2005 budget indicates that these are now called Global Strike Planning Documents. The new Joint Nuclear Doctrine refers to Theater Nuclear Planning Documents. SWPS budget item, PE 0101313F February 2004; Doctrine for Joint Nuclear Operations, Final Coordination, 3 September 2003; Universal Navy Task List, 1 May 2001, Task AN 3.2.1.

46. Statement of Objectives for SWPS modernisation, 22 January 2004.

47. Joint Staff Input to the Doctrine of Joint Theater Nuclear Operations, JP 3-12, 2003.

48. Doctrine of Joint Theater Nuclear Operations, JP 3-12, Final Coordination, 3 September 2003.

49. Pheonix Force Structure Review, STRATCOM 24 August 1991, partially declassified and obtained under the FOIA by H Kristensen.

Annex E
NATO Nuclear Planning system

NATO / US nuclear co-ordination

Prior to the creation of STRATCOM, the Joint Strategic Target Planning Staff (JSTPS) carried out strategic nuclear planning. An officer of Brigadier General rank represented the senior NATO commander, SACEUR, at JSTPS. He worked with the Deputy Director of the nuclear planning staff.[1] This liaison has been described as an interface between the planning agency (JSTPS) and the executing command (SACEUR).[2] JSTPS coordinated NATO's plans with the US strategic nuclear plan, SIOP.[3] Its work was also described as "combined (US/NATO) nuclear targeting".[4]

Guidance on US nuclear planning, written in 1996, refers to Major Contingency Options (MCOs) prepared by SACEUR. It also says that the SIOP should be tested in an annual war game. The war game should analyse "the potential contribution of SACEUR's MCOs".[5] Following the war game, STRATCOM should recommend improvements in "SIOP and MCO coordination".[6] The guidance document is heavily censored and further details are not apparent. It is likely that coordinating the SIOP and NATO's plans (MCOs) has been a significant feature of US nuclear planning.

The outline of the US Air Force Europe (USAFE) operations plan (OPLAN) for the Defence of Western Europe, 1997, shows that USAFE maintained its own detailed nuclear options.[7] One of the columns describing these options was for the NATO number allocated to each nuclear target.[8] The US has dominated nuclear planning within NATO. It is likely that details of the nuclear options in NATO MCOs were extracted from the options in the USAFE OPLAN.

Plans for the use of Sub Strategic Nuclear Forces by NATO will have been produced in Europe, with support from Omaha. Detailed target planning for NATO use of Strategic Nuclear Forces, such as US and British submarine-launched ballistic missiles, is likely to have been carried out within JSTPS and its successor STRATCOM.

The US had a strong grip on the old process for drawing up NATO nuclear plans. The recent shift, from pre-prepared plans to adaptive planning, has probably increased US control over NATO nuclear planning.

Standing NATO Nuclear Plans

During the Cold War NATO maintained lists of nuclear targets and detailed plans to use nuclear weapons against them. Today the alliance says that it no longer keeps standing nuclear attack plans. In 1999 the NATO Strategic Concept referred to "the termination of standing peacetime nuclear contingency plans".[9] A later briefing on NATO Nuclear Forces said: "With the end of the Cold War NATO terminated the practice of maintaining standing peacetime nuclear contingency plans and associated targets for its sub-strategic nuclear forces".[10] For several years after the end of the Cold War NATO Dual Capable Aircraft were still kept on a high state of alert. It was only in 1995 that this alert state was reduced – it was no longer measured in minutes, but weeks. In June 1996 the Nuclear Planning Group said that alliance nuclear forces "are no longer targeted against anyone." It is likely that NATO stopped maintaining standing nuclear plans between 1995 and 1998.

NATO Nuclear Planning System

Today NATO Sub-Strategic Nuclear Forces are made up of some single-warhead British Trident missiles plus Dual Capable Aircraft from the USAF and four European Air Forces which can drop US nuclear bombs. Britain's strategic nuclear force is also assigned to NATO.

Although the alliance says that it no longer has static nuclear plans, it has developed and enhanced a computerised network that can rapidly create such plans. The NATO Nuclear Planning System (NNPS) was started in 1990 and initial work was completed in 1996.[11] It was designed to help NATO staff plan nuclear missions. It was to be able to support both Major Contingency Options and Selective Contingency Options. NNPS was modified between 1996 and 2002. Further work to upgrade the hardware and software was started in 2004.[12]

NNPS assists in the selection of targets and indicates which nuclear weapons should be used against each target. It then compares a number of planning options for carrying out the attack.[13] The central computer for NNPS is based at SHAPE. This can be accessed from a number of remote PC workstations, both fixed and mobile, some at nuclear airbases.[14]

In 1996 the NATO Nuclear Planning Systems Target Data Feed (NNPSTDF) project was initiated to give NNPS better access to data from US systems. The NNPSTDF interface was designed to operate in two ways. In peacetime it provides the capability for NATO to receive large volumes of data for long term planning. The second way the interface operates is to support adaptive planning.[15] It can be used to track "fleeting" targets and also to update air defence files.[16] The time taken to produce NATO nuclear attack plans has been reduced. The new system provides "near real time intelligence information" for nuclear planning.[17] This development has been influenced by US proposals to use nuclear weapons in Counter Proliferation operations.[18]

NNPS receives target data through two US systems. Some data is obtained via EUCOM, the US command structure in Europe. Other information is obtained directly from STRATCOM.[19] Lists of installations, facilities, equipment and units, which could be potential targets, were previously taken from EUCOM databases.[20] Under the new system they are downloaded from a central US database, the Modernised Integrated Database.[21] This is accessed through a workstation on the Linked Operational Command centres Europe (LOCE) network. LOCE is a US EUCOM system.[22]

The direct link from STRATCOM to NNPS provides data to estimate how many attacking aircraft would be destroyed by enemy air defences.[23] It also supplies information on intervals between nuclear strikes - fratricide separation distances. This direct feed from STRATCOM in Omaha handles Top Secret material, whereas LOCE can only supply data classified up to Secret.

By 2002 further integration had been carried out between NNPS and ISPAN, the central US nuclear planning system.[24] Recently an interface was also established between NNPS and the Air-vehicle Planning System (APS). APS is the component of ISPAN that plans aircraft missions. In addition, the unique features of the NATO system are taken into account in some elements of ISPAN, including the software used to build lists of nuclear targets.[25]

Descriptions of NNPS show that it can, possibly exclusively, plan missions for Dual Capable Aircraft. One contract says that it "assists nuclear operations staffs in several phases of targeting and planning air missions."[26] Many of the data files referred to above are only used for planning aircraft operations.[27] There is no indication that, at the time of this contract (1997), NNPS was able to plan attacks involving Trident missiles. It is possible that such a capability was added later, but there is no sign of this.

NNPS includes a Nuclear Consultation Subsystem (NCS). This can automatically create Power Point presentations to illustrate nuclear attack plans. These are used to brief the representatives of allied countries in the nuclear consultation process.[28]

Nuclear Planning expertise

During the Cold War nuclear weapons played a key role in NATO strategy and so the planners at SHAPE required a basic knowledge of the effect of these weapons. The declining significance of nuclear arms within the alliance has meant that there are fewer people at NATO headquarters who know how to plan nuclear attacks. The authors of a recent US report raised this issue with staff at STRATCOM. They concluded - "nuclear expertise at theater level has atrophied".[29] This ignorance could act as a force of restraint, but it could also result in nuclear options, which underestimated the effects of fallout, being proposed and even implemented.

The Nuclear Consultation process is rehearsed in an annual NATO exercise ABLE TEAM. NNPS is tested each year in the ABLE ALLY nuclear strike planning exercise. For these war games scenarios will be created which could result in NATO using nuclear weapons.

Even at the height of the Cold War NATO nuclear planning existed in a parallel universe. It had its own logic, yet it was detached from the day-to-day experience of its participants. Today the scenarios used must be so unlikely that the process will be totally disconnected from reality. The participants in these war games may be left questioning whether these weapons could ever have any military value.

Command Systems

US military forces are organised into geographical commands, one of which is US European Command (EUCOM). EUCOM's area of concern extends beyond Europe and includes Africa and Russia.

The key officers are dual-hatted. The Commander of EUCOM is also the NATO Supreme Allied Commander Europe (SACEUR). The British Commander-in-Chief Fleet is also the Commander of NATO Naval Forces North. He is in operational command of Trident from his headquarters at Northwood.

US nuclear weapons deployed in Europe can be used under either EUCOM or NATO command structures. US personnel who are responsible for B61 bombs on the ground need to be familiar with both EUCOM and NATO Emergency Action Procedures.[30]

During the consultation into the new US Doctrine for Joint Nuclear Operations, several agencies pointed out that the document did not clearly state how plans for US nuclear bombs in Europe were produced. In response the editor added a line to the Doctrine saying, "EUCOM has a unique nuclear command and control relationship with Supreme Headquarters Allied Powers Europe".[31] He pointed out that it was not possible to explain this further in an unclassified publication.

EUCOM maintains control over a key aspect of the weapons. The B61-3/4/10 bombs have Permissive Action Links (PAL), a digital locking system. The bombs can only be armed if the correct code is entered. The PAL system is monitored and operated by EUCOM rather than NATO.

US operations are managed by the EUCOM Plans and Operations Center (EPOC). Within EPOC there is a Joint Nuclear Operations Center (JNOC). JNOC is a US unit, however it can deploy a liaison cell to Supreme Headquarters of Allied Powers in Europe (SHAPE) to support NATO nuclear operations.

In addition to the land-based headquarters, EUCOM also has an Airborne Nuclear Command Post. This is crewed by nuclear command and control staff from EPOC. It is able to control nuclear attacks by Dual Capable Aircraft and Sea-Launched Cruise Missiles.[32]

EUCOM operates the Non Strategic Nuclear Forces Command and Control and Communications System (NSNFC3S). There are NSNFC3S terminals in Command Posts at airbases which have a nuclear role.[33] In 1998 a contract was issued for a study for both NATO and EUCOM. This would examine "theater requirements for automation to improve the command and control of nuclear assets."[34]

In 2002 STRATCOM's central nuclear planning system, in Omaha, was integrated into systems operated by EUCOM and other geographical commanders. They also all now use the same database of potential targets.[35] The Air vehicle Planning System (APS) is the programme used at Omaha to plan nuclear attacks by aircraft and air-launched cruise missiles. APS has been integrated into the command systems used at EUCOM and other US theatres.

Notes

1. Brigadier General J Myers, Biography, US Air Force.

2. Major General JF O'Malley, JSTPS Air University Review May-June 1977

3. ibid

4. Col MC Christian & Major JE Dillard, Why we need a National Joint Targeting Center, Air & Space Power Chronicles, Jan 2000.

5. Nuclear Supplement to the JSCP for FY 1996 CJCSI 3110.04, partially declassified and obtained under the FOIA by H Kristensen.

6. ibid

7. Planning Formats and Guidance, USAF Manual 10-401 Vol2, 1 May 1998.

8. NATO nuclear plans identify targets by Allied Command Europe Designated Ground Zero Numbers (AND). Ibid

9. The Alliance Strategic Concept, 24 April 1999

10. NATO Handbook: NATO Nuclear Forces in the New Security Environment, June 2004 www.nato.int/issues/nuclear/sec-environment.htm

11. Several military glossaries refer to the Allied Command Europe Integrated Nuclear Planning System (AINPS). This may have been replaced by NNPS. There is also a reference to the Allied Command Europe Nuclear Planning Process (ANPP) – JSCP-N FY1996 CJCSI 3110.04, partially declassified and obtained under the FOIA by Hans Kristensen.

12. Funds were allocated to "upgrade and enhancements to hardware and software systems supporting the NATO Nuclear Planning System" NATO Security Investment Program (NSIP), US Budget FY2004

13. Modification one to Statement of Work for NPSTDF, Defence Special Weapons Agency para 1.2

14. Statement of Work, Support to NPES and Joint Staff Nuclear NATO systems, contract to Encore IT solutions, 22 July 2002

15. ibid

16. Modification One to Statement of Work for NPSTDF, Defence Special Weapons Agency

17. NPSTDF, DSWA, CBD 22 May 1996

18. Planning Systems for Contingencies Involving Proliferants, Chemical Biological Defense and Nuclear Defense Technology Objectives.
http://www.fas.org/spp/military/docops/defense/dtap_dto/cb_dto.htm

19. Modification One to Statement of Work for NPSTDF, Defence Special Weapons Agency

20. This is referred to as EUIDAB, which is probably the USEUCOM Integrated DataBase.

21. Since 1997 the US has used as its main source of target data the Modernized Integrated Data Base (MIDB). The NPSTDF system was introduced partly to respond to the introduction of this common US target database.

22. In addition to the live network, a tape backup is produced by the Joint Analysis Centre at RAF Molesworth for NNPS.

23. Described as SAM attrition rate and Fighter attrition rate files.

24. RDT&E Project Justification, 060271BR Nuclear Operations, February 2003

25. Engineering Services for Maintenance and Enhancement of NTB and DGZ List Integration Development System Version II (NIDS II) software, FBO Daily 16 July 2003.

26. Modification One to Statement of Work for NPSTDF, Defence Special Weapons Agency

27. They could possibly also be used for Cruise Missile missions, but there is no direct reference to this.

28. Some of the presentation is created automatically from target data in NNPS, other parts are entered manually by planning staff. NNPSTDF, DSWA, CBD 7 Jan 1998

29. Buchan op cit p103.

30. USAFE Command Posts, USAFE Instruction 10-207, 31 December 2003.

31. Joint Staff Input to the Doctrine for Joint Nuclear Operations, 28 March 2004.

32. USEUCOM Theater Command and Control Policy, ED 55-11, 28 June 2004.

33. USAFE Command Posts, USAFE Instruction 10-207, 31 December 2003.

34. Statement of Work for European Theater Nuclear Forces Improvement Program, DSWA 1998

35. Project BG-Nuclear Operations, Exhibit R-2a, RDT&E project justification, Feb 2003.

Annex F
Trident Targeting and Fire Control

While the main centre for US nuclear war planning is Offut Air Force base in Omaha, Nebraska, in the case of Trident the focus of activity is the Naval Surface Warfare Centre, Dahlgren Division (NSWCDD), in Virginia. K40 branch at NSWCDD are responsible for Submarine Launched Ballistic Missile (SLBM) research and analysis. K50 develop SLBM software. These branches carry out work for both the American and British Trident programmes.

There are two processes: *Target Planning* is the preparation of plans to attack targets with a series of RVs on a number of missiles on one or more submarines. It is carried out on shore or in airborne command posts. *Fire Control* is the preparation of instructions to launch one or more missiles. Fire Control is carried out on the submarine.

There is substantial duplication between the two stages. Calculating the performance of Multiple Independently Targeted Re-entry Vehicles (MIRVs) fired from a moving platform is complex. The shore-based target planning system replicates many of the final calculations of the Fire Control System (FCS) to assess if a proposed attack plan is feasible and if it would achieve the required accuracy.

Instructions prepared in the Target Planning process are supplied to the Fire Control System (FCS) on the submarine. These two systems have to be compatible. Britain uses the same FCS as the US. The British target planning system uses US software.

The following sections consider key aspects of target planning and fire control:

- SLBM Retargeting System
- Development infrastructure
- Fire Control Hardware

- Fire Control Software
- Target Planning
- Models
- Factors
- Tape and message Production

SLBM Retargeting System

The SLBM Retargeting System (SRS) has substantially speeded up the process of retargeting Trident missiles.[1] It has resulted in substantial upgrades to the target planning systems and FCSs used by both Britain and America. The development of SRS began in October 1989, one month before the fall of the Berlin Wall. It was implemented in three phases. The final phase became operational on US submarines in October 2003.[2] SRS would enable Trident submarines "to quickly, accurately and reliably retarget missiles to targets", and "to allow timely and reliable processing of an increased number of targets".[3] The system would "reduce overall SIOP processing" time and "support adaptive planning".[4]

There are three reasons why Trident has been made more flexible. Firstly a small number of Trident submarines are deployed as the Secure Reserve Force. The missiles on these submarines would be held back till the final stage in a strategic nuclear exchange. The targets assigned to this force could alter as a nuclear conflict unfolded. Secondly US planners have been very concerned about how to destroy Russian road-mobile SS-25 and rail-mobile SS-24 ICBMs. A rapid retargeting capability would increase the chance of destroying these weapons. Thirdly the flexible system is in keeping with the US desire to be able to use nuclear weapons against any part of the world at short notice.

When asked about SRS, Adam Ingram replied "The UK has no requirement for a SLBM Retargeting System on Trident submarines, and has no plans to acquire that capability".[5] This is a misleading answer. Britain has purchased hardware and software for the new FCS which is at the core of SRS. The new fire control computer entered service on the first Vanguard class submarine one month before the final phase of SRS was fully operational in the US.

Before SRS was operational a parallel system was introduced for land-based ICBM. Development of the Rapid Execution and Combat Targeting (REACT) system started during the 1980s. When REACT entered service in 1995 it halved the time needed to change the full target plan, from 20 to 10 hours. A single missile could be retargeted in a few minutes.[6] As well as speeding up targeting, REACT also automated the way in which launch instructions are processed for ICBM. In the past several copies of each messages were printed, manually checked, decoded and if necessary corrected. The resulting data was then typed into the launch control computer. With REACT the instruction is received in a format similar to email. This is decoded and checked automatically.

Development infrastructure

NSWCDD employs computer scientists and mathematicians in advanced computer work. Some of their projects are contracted out to the private sector. In the early days of Polaris the most powerful computer in the world was the one at NSWCDD used to prepare targeting for these missiles. With the introduction of MIRV on Poseidon and then the increased accuracy requirements of Trident, the computing demands increased. In the 1990s the IT resources of NSWCDD were used to increase the speed with which Trident can be retargeted.

The system on which software is developed at NSWCDD is the Distributed Graphics SLBM Network (DGSNET). This is used by K41 to develop Fire Control software for the US and Britain.[7] DGSNET is also used for target planning and it handles target data for the US system.[8] In 1997 the operating system was modified so that fire control software, simulation models and target data from DGSNET would run on the upgraded Trident Fire Control System.[9]

In addition to DGSNET there is an SLBM Internet-to-Desktop System.[10] The overall system is also described as the SLBM Computing Environment (SCE).[11] SCE is based on a E10K server.[12]

Fire Control System Hardware

The Fire Control System (FCS) hardware on Trident submarines is the Mk 98 Fire Control system produced by General Dynamics Defense Systems (GDDS). This carries out calculations to prepare and launch the missiles.

The FCS has been upgraded for two reasons. The retargeting system SRS requires more computing power. In addition there has been a switch to commercially replaceable and upgradeable components under the Life Cycle Cost Control scheme.[13]

Two variants of the new FCS are being produced. US Trident submarines will have the Mk 98 Mod 4. This was first installed on USS Alaska in 2000.[14] British vessels will use the Mk 98 Mod 5. Contracts for software and hardware suggest that the two systems are very similar.

In 1999 the US Navy sought a contract to upgrade three British FCSs to Mk 98 Mod 5. One of these was on a submarine and the other two were shore-based systems. The contract said there would be further orders in future years.[15] It is likely that one of the shore-based FCSs is a test rig at Devonport and the other is in the Strategic Weapons training facility at Faslane.

The new FCS entered service on all British Trident submarines between September 2002 and February 2003.[16] In January 2003 the US sought to appoint an adviser to help the Royal Navy as the Mk 98 Mod 5 entered service. This person was initially to work at the Strategic Weapons Test Organisation at Devonport and later at Faslane.[17]

Adam Ingram, the Armed Forces Minister, said that the total cost of the hardware for the four new systems was $39.8 million, plus $7 million for initial spares.[18] This is equivalent to $11.7 million for each FCS. However the budget for installing similar systems on US submarines gives the unit cost of the Mk 98 Mod 4 as $19.8 million.[19]

The old FCS was a 1970s design with one central computer which had 1 Mb of memory. This is a small fraction of the memory on an average home computer today.[20] The new system has four computers networked together. Each one is based on a commercial Power-PC. The four units are described below.

Data Entry Sub System (DESS)

DESS handles target data. It enables the missiles to be used against a wider range of targets. Pre-arranged targets are loaded from 4 mm tape.[21] DESS can also receive target data transmitted to the submarine by radio. The new computer has increased storage capacity and can keep a larger number of targets in its database. DESS reads geodetic, bathymetric and gravitational data supplied on tape or CD and stores this information. It also maintains the overall system.

Display and Control Sub System (DCSS)

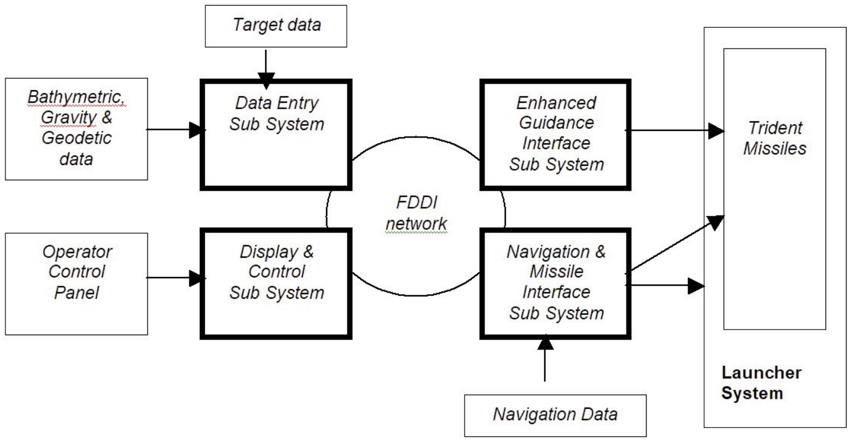
The missile operator sits at an Operator Control Panel, a series of colour coded buttons. DCSS is the computer behind this panel and it implements the commands issued by the panel.

Enhanced Guidance Interface Sub System (EGISS)

EGISS produces instructions for the guidance systems on each missile. EGISS carries out pre-launch guidance processing and sends data to the guidance modules on each missile.

Navigation and Missile Interface Sub System (NMISS)
NMISS receives data on the submarine's position from the Electrostatically Supported Giro Navigation (ESGN) and other navigation systems. It sends information to the Flight Control Systems on each Trident missile.

Mk 98 Mod 4 / 5 Fire Control System



The quality of the hard drives and other components on the FCS is checked by EG&G, the main Trident contractor at NSWCDD. EG&G discovered faults within the "tactical hard drives" of part of the Trident system, which may have been the FCS. The problem was described as a "firmware bug", which probably refers to the commercial drivers.[22]

The US is developing the Mk 98 Mod 6/7, a further modification of the FCS.[23] It is possible that Mod 6 will be for US submarines and Mod 7 for British submarines.

Fire Control System Software

Separate applications run on the four computers in the new FCS. The targeting application runs on DESS. This updates the target database and assigns targets to missiles. The pre-launch application runs on EGISS. This prepares the missile guidance system prior to launch, calculates steering data for the missile and coordinates the launch sequence. There are over 1 million lines of code in the new FCS software.[24] It includes a trajectory model.

K Department of NSWCDD develops the software for the FCS on both British and US submarines. They have awarded contracts to General

Dynamics Defense Systems for some of this work.[25] The contracts show that the UK uses similar, if not quite identical, software. This software is identified by a three digit number. In 1995 contracts were awarded for "633" software, while by 2002 the reference is to "640" software.[26] Software ending in "38" was designed for use on the new FCS.[27] The Final Qualification of "UK X38" software was due in 2002. This is consistent with the new system entering service on Vanguard class submarines from September 2002. It is likely that the difference between US and UK versions of the software is that some data and components, classified "US Eyes Only", are omitted from the version supplied to Britain.

In 2002 the US awarded a $48.5 million contract to CACI for software testing and support for FCS software until 2009.[28] The UK will pay 10% of this. When asked about the cost of software for the new FCS, the Armed Forces Minister Adam Ingram replied "information on the costs of related software modifications is not held separately from that relating to other software costs in this area."[29]

Intent Word

Intent Word is a crucial signal sent to the nuclear warhead. The warhead is designed so that it should not detonate before this signal is received. The signal opens the "intent stronglink", a safety feature in the warhead.

The "Intent Word" is sent from the FCS to the missile immediately before launch. When the missile is in flight this signal is transferred to the warhead.

In December 2004 the US Navy was seeking a contract for Fire Control Software and "development of UK Intent Word".[30] In April 2005 a contract was issued for "UK intent word displays" for the Mk 98 Mod 5 FCS.[31] A special British version of this important system is produced in the US.

Target Planning

NSWCDD have created a computer programme called the SLBM Integrated Planning System (SIPS). SIPS appears to be the main application used in the US for planning Trident missions.[32] The software installed in the computers at the British targeting centre, NOTC, is based on American models. It is probably derived from SIPS.

Planning and evaluation

SIPS is a planning tool. It has been described as "a set of integrated computer based planning tools."[33] It can translate a list of targets into a detailed plan, allocating targets to a large number of RVs on many missiles on a number of submarines. Its function has been described as "target base management".[34]

SIPS is also an evaluation and analysis tool. It has components which model various aspects of Trident missile operations. It can test proposed modifications. It was also used as a simulation alongside the Arsenal Exchange Model (AEM).[35] AEM was used to simulate global nuclear war and is to test the SIOP.

NSWCDD and STRATCOM

US nuclear war planning is coordinated in the ISPAN system run by STRATCOM at Omaha. NSWCDD is networked into ISPAN and carries out critical Trident functions. A diagram illustrating the nuclear planning computer structure in 1998 showed that NSWCDD is part of the main network. The workstations at NSWCDD were using the same platforms and operating system as STRATCOM.

In 2003 a list was produced of programs related to the main Strategic War Planning System (SWPS), since renamed ISPAN. This list says that SIPS was to be delivered by NSWCDD representatives to SWPS. SIPS is now incorporated into the Missile Graphic Planning System (MGPS) at STRATCOM.

STRATCOM coordinates nuclear war planning, allocates targets to Trident, and predicts the effect of these missions within the overall planning option. However they do not produce the final data for the submarines. They provide information to NSWCDD who then produce detailed target plans in tape or radio-message form. The work is divided between the Air Force, at STRATCOM, and the Navy, at NSWCDD.

Deliberate and Adaptive Planning

SIPS is used for "Deliberate and crisis planning of SLBM weapon systems".[36] Deliberate planning is the preparation of detailed proposals in advance, primarily the production of the annual US strategic nuclear plan, OPLAN 8044. Crisis planning includes adjusting targets to cope with a changing situation in a strategic nuclear exchange, and preparing to attack new targets anywhere in the world. The use of SIPS for crisis or adaptive planning is confirmed in a NSWCDD presentation which says that the programme "supports SLBM Retargeting System effort".[37]

Two other programmes are also used to rapidly retarget Trident missiles. Direct To Force and the SLBM Adaptive Targeting System (SATS) are both installed on nuclear command aircraft.[38] These two applications would prepare messages to retarget Trident missiles during a strategic nuclear war. SATS may be used more widely. It may have been incorporated into SIPS, or operate in tandem with SIPS.

SIPS activities

An NSWCDD briefing describes five areas which SIPS addresses:[39]

- Footprinting. The footprint is the area within which RVs on a single missile can land.
- Sequencing. This is calculating the order in which the RVs should be deployed.
- Fratricide. This is the destruction of one RV by the detonation of another.
- Launch area analysis. This is assessing whether the proposed attack plan can be carried out at all points within a submarine's patrol area.
- Achievability. This is verifying the ability to destroy a package of targets taking account of the factors listed above.

Target-Planning and Fire Control Compatibility

The data created by SIPS is fed into the Data Entry Sub System (DESS) on the submarine, either by tape or radio. The two systems will be compatible. An IT company, Geologics, was given one contract to review the human-computer interfaces on both DESS and SIPS.[40] This suggests that DESS and SIPS are regarded as parts of one system. On British submarines the target data is inserted into almost identical DESS computers. This also indicates that the British shore-based target-planning system uses SIPS or similar American software.

Models

US programmers have created a series of models to support Trident. Parts of these models are incorporated in fire control and target planning applications. The Applied Physics Laboratory at John Hopkins University (APL) has produced some of the models. APL assesses missile tests from British and American submarines. The tests use Joint Test Assemblies (JTAs). These are special RVs with dummy warheads and telemetry equipment. The path of the JTA is tracked and the performance of warhead components monitored. A new JTA for the W76/Mk4 was developed between 1997 and 2004. This provides 10 times more data than the previous model. An second version, JTA4A-2B, has been designed to simulate the new modification of the Trident warhead, W76-1. Data from flight tests with the new JTAs will be used to improve the computer models.

A briefing on the work of K Department at NSWCDD says that there are models for trajectory, environment, accuracy and field flow.[41] These models can be run independently or they can be combined.

A symposium on computer modelling and simulation for Trident was held in October 2002. Presentations given at this meeting provide some information on the Weapon System Accuracy Model, OD 55340. OD 55340 includes over 900 tables of data and has been updated 30 times.[42] Parts of OD 55340 are "embedded in tactical software", i.e. they are incorporated within the programmes used in the FCS on the submarine and/or in the SIPS target planning application.[43] OD 55340 is also used to assess the current accuracy of Trident and to predict the effect on accuracy of any proposed changes to Trident operations. The subsystems of OD 55340 appear to be: Navigation, Fire Control, Guidance, Deployment, Fuse, Aerodynamics, Winds & Density, and Environment.

Advance notice of a contract for Trident software support, issued in July 2005, requires the contractor to verify up to 15 models "including Fire Control (FC) support software, United Kingdom (UK) reference/simulation models, US/UK targeting models and SLBM general purpose tools."[44] This contract proves that at the heart of the software used for British target planning and fire control are models developed in the US. An American contractor carries out quality assurance of these models. The difference between British and American versions of the software is that some classified material is removed before the applications are supplied to the UK.

Factors

Trident D5 is a three-stage solid-fuelled missile. With the submarine operating at a shallow depth the missile is ejected by the launcher system. The first stage ignites. When this is exhausted the second stage ignites, then the third. At the front of the missile is a Post Boost Vehicle (PBV) on which there are several Re-entry Vehicles (RVs), each of which contains a nuclear warhead. After all three stages have fallen away, gas generators on the PBV produce power to manoeuvre it into position to spin-off the first RV.[45] The PBV then adjusts its position to release the second RV, etc. The initial boosted flight and the PBV manoeuvring take place within the first third of the trajectory. The RVs themselves are not powered and the remaining two thirds of the trajectory is ballistic. Each RV falls on a separate aimpoint.[46]

Trident D5
Post Boost Vehicle with W76 warheads

(A British Trident missile will have either 1 or 4 warheads.)

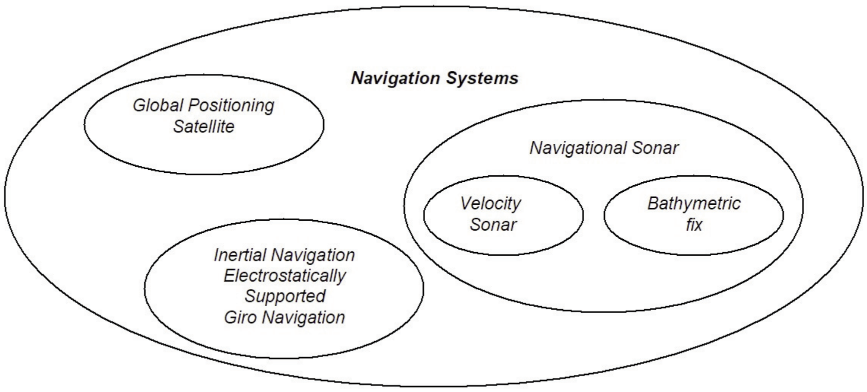
Accuracy was not the primary factor in the design of Polaris, Poseidon or Trident C4 missiles. However it was a key goal when Trident D5 was designed. This was because the D5 was to be able to destroy missiles in their silos and command bunkers. To achieve this, improvements in accuracy were sought across a range of missile components and factors. A system-wide approach to accuracy was adopted.[47] So Trident D5 fire control and target planning is complex. Some of the key issues are considered below.

Navigation

Unlike a land-based ICBM, a Trident missile is launched from a moving platform. Calculations have to be adjusted at the last moment to take account of the vessel's position. Errors in the calculation of the launch position are magnified across the missile's trajectory. US submarines use three systems to calculate their position: GPS, Inertial and Navigational Sonar. There is built in redundancy so that Trident is not dependent on one navigation system.[48]

Global Positioning Satellite

The Global Positioning Satellite (GPS) system was designed to support nuclear submarine operations. From time to time the submarine takes a fix to determine its position using signals from GPS satellites. These signals cannot be received under the water so an antenna must be raised above the surface. This could compromise the submarine's position. US nuclear planners anticipate that exoatmospheric nuclear explosions in a strategic nuclear exchange could cripple GPS. Because of these risks additional systems are used so that Trident is not dependent on GPS.



Inertial Navigation
Between GPS fixes the direction and speed of the submarine is monitored by the Electrostatically Supported Giro Navigation (ESGN) system. ESGN uses accelerometers to measure changes in speed and gyroscopes to monitor changes in direction. Data from ESGN is fed into the FCS computer. The velocity data provided from ESGN is not considered sufficiently accurate, on its own, for a Trident missile launch.[49] It is correctly primarily by the Navigational Sonar System, and secondly from an electromagnetic log of instructions issued to manoeuvre the submarine.

Navigational Sonar
US Trident submarines use a Navigational Sonar System (NSS). The main component of NSS is a velocity sonar which can measure the speed of the submarine. This complements GPS and ESGN to provide greater accuracy.

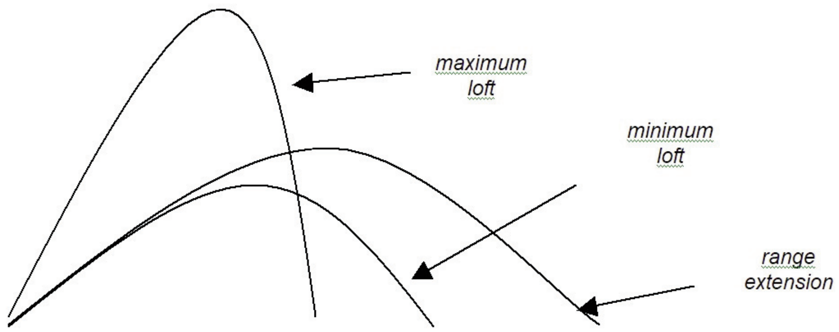
NSS can also measure the depth of the seabed.[50] The submarine sails over a pre-surveyed area. A series of depth readings are compared with a computerised bathymetric map to provide a fix of the submarine's position.

The Navigational sonar used on US Ohio class submarines is the BQR 19 produced by Raytheon. This includes a transducer and an array of 16 hydrophones which measure speed. The NSS is in addition to active and passive sonar systems that are used to detect other vessels.

British submarines use the same GPS and ESGN systems as US vessels. Descriptions of the sonar systems on Vanguard submarines do not refer to Navigational Sonar. However when the Strategic Defence Review, in 1998, reduced the alert state of these submarines it was said that in future they could carry out hydrographic work while on patrol. This suggests that they have a navigational sonar system.

Trajectory options

The angle of the missile's trajectory affects the range, time of flight and velocity of the RVs. The following terms are used to describe the extremes of the options available:[51]



- Range extension – This is used to attack targets at the limit of the missile's range. The reentry angle is shallow. As a result the shape of the RV is distorted by ablation. Rain and wind have a greater effect. This means that accuracy is reduced as range increases. Flight time is longest.
- Maximum loft – This uses the steepest possible trajectory. Range is reduced. Velocity is increased and there is a steeper re-entry angle. Consequently accuracy is greater. As the trajectory is higher it is easier for the opponent to detect the attack.
- Minimum loft – This reduces the trajectory below that which would give maximum range. The re-entry angle is shallow, which reduces accuracy. This has the shortest flight time and so is likely to be used in a surprise attack.

When using missiles against an area protected by Anti Ballistic Missiles (ABMs) it is possible to fire the missiles on different trajectories so that they will arrive around the same time and flood the ABM defences. The British plan to attack targets in and around Moscow with Chevaline may have used this tactic.

Footprinting

The four RVs on one missile can be used against four separate targets but all these targets for have to be within an ellipse called the footprint. The type of trajectory affects the size of the footprint. If the range is greater, then the length, downrange, of this ellipse increases. When a minimum loft trajectory is used the breadth, crossrange, of the ellipse decreases.

A Poseidon missile fired at a range of 500 nautical miles (nm) had a footprint length of 150 nm. At a range of 2000 nm this increased to 300 nm. Footprint breadth was 200 nm for maximum loft trajectories at ranges between 700 and 1500 nm.[52] The range of Trident D5 is over 4000 nm, more than double that of Poseidon. The footprint of the Trident missile will be substantially more than that of Poseidon. The minimum range of Trident is a constraint. It may be between 500 nm and 1000 nm.[53]

Sequencing

The order in which the RVs are allocated to targets within the footprint is crucial. Sequencing restrictions mean that in some cases it is not possible for the PBV to manoeuvre so as to deploy all the RVs, even though all the targets are within the footprint.

Time of Flight

The FCS calculates a Time of Flight (TOF) for each RV on each missile.[54] TOF is one of the key variables used in planning Trident attacks.

Re-entry envelope

The flight path of a Trident missile takes it outside the earth's atmosphere. If an RV re-enters at the wrong angle then it will be destroyed during re-entry. The acceptable limits are described as the survival envelope. The trajectory of each RV is adjusted to keep it within this survival envelope.

Fratricide

Two warheads are often targeted on the same installation or on two facilities close to each other. The first explosion can prevent the second warhead from detonating.[55] If the warhead arrives too soon it is neutralised by gamma and neutron radiation. If it arrives too late it has to pass through the fallout cloud and ionised atmosphere. This can prevent the warhead from functioning. There is a narrow window of time within which the second warhead has to arrive. The targeting system also calculates a stay-out zone for each RV. This is an ellipse down-range of the initial target.[56] A subsequent RV cannot be used against a target within this stay-out zone.

Minimum Energy

The limited fuel carried on the PBV limits targeting options. The FCS computer calculates how to manoeuvre the PBV to align all the RVs using minimum energy.

Guidance

The Trident D5 missile uses inertial and stellar guidance systems. The gyroscopes and accelerometers in the inertial guidance system monitor the trajectory of the missile. In addition the stellar system takes a fix on two stars.[57] NSWCDD has produced the Dahlgren General Catalog of stars to support this function. Trident missile guidance and fire control systems use this database of stars, their position and brightness. The FCS identifies an appropriate star taking account of geography and time. GPS may be used for additional accuracy, but GPS satellites are considered to be vulnerable in a strategic nuclear war.

Plume Avoidance Manoeuvre

The nozzles that manoeuvre the PBV each create a plume. This can distort the trajectory of an RV which has just been released from the PBV. If this is projected to be the case then the nozzle which might cause this problem is switched off for a short period. The PBV then manoeuvres to regain its course. This is called a plume avoidance manoeuvre.

Reentry Vehicle Spin Off

The RV spins when in flight. This is to even out the effects of ablation and heat absorption. This is similar to rotating meat on a spit so that it will cook evenly. Spinning also maintains the correct attitude for reentry. The RV is given a spin as it is released from the PBV by a "pyrotechnic deployment mechanism", ie a small explosive charge.[58]

The velocity of the RV is increased as it is spun off. This velocity increment is included in the trajectory model. It is regarded as a source of error but it is not precisely know. A programme is underway to measure this velocity increment. For this project Honeywell Incorporated have developed the Reentry Inertial Measurement Unit (RIMU). RIMU has been used on the dummy warheads, Joint Test Assemblies, in recent Trident missile tests.[59] Honeywell claim "effective improvement in the down range impact miss was accomplished in all RIMU units flown".[60] It is likely that the accuracy increase deriving from this project is small.

RIMU is not just a US programme, it is partly financed by Britain. A joint US/UK contract for an enhancement of RIMU was issued in April

2001.[61] In 2003 a contract was issued for the development of a smaller unit, SRIMU.[62] SRIMU is to be used to analyse RV trajectories. There is no mention of UK funding, although this is possible.

Decoys and Penetration Aids

A missile may use decoys and penetration aids in order to overcome Anti Ballistic Missile (ABM) defences. Decoys are mounted between RVs on the PBV. They are smaller than RVs but are designed to give a similar radar signature. The fire control software will calculate when the decoys should be released from the PBV.

Fusing

There are radar systems onboard each RV. These can trigger a high-airburst or low-airburst explosion. Timing can also be used. The new version of the W76 warhead, W76-1, will also have a contact fuse to detonate the explosive on the surface. In addition the refurbished warhead will have a "path length" fusing system. This combines timing and radar data to monitor the RV's position on the predicted trajectory. (This is describe in Annex I)

Aerodynamics

During and after re-entry the trajectory is affected by the aerodynamics of the RV. RVs fly at speeds of between Mach 15 and 20 outside the atmosphere, slowing to Mach 10 following re-entry.[63] During re-entry the RV is subjected to extreme heat. This is absorbed by ablation, burning off the outer later of the casing. This changes the shape of the nosetip and consequently affects the aerodynamic performance of the RV. Computer modelling is used to predict this. Uneven ablation was identified as the cause of inaccuracies discovered during initial tests of the Mk 4 RV. The design of the Mk 5 RV was adjusted to take account of this.

Weather data

Air density and wind can affect the RV in the final stages of the trajectory. Weather can knock the RV 100 m off-target. To get round this the US Navy produces detailed weather forecasts over the target areas. Communications with submarines are limited, because of the low bandwidth of transmissions. So the weather information is compressed into Ballistic Parameters (BALPARs).[64] BALPARS approximate the total effect that wind and air density at different altitudes would have over the final stages of an RV's flight path. BALPARs are calculated for fixed points in a grid and are produced by the US Fleet Numerical Meteorological and Oceanography Center (FNMOC). FNMOC send the BALPARs to the Commanders of the Trident fleets in the Atlantic and Pacific. The information is sent by radio to Trident submarines every 12 hours.

A key requirement of Britain's Trident system is that the submarines have "access to all environmental data".[65] This probably includes the FNMOC data from the US. The data will be transmitted to the submarines either directly from the US, or through Northwood. NSWCDD has carried out metrological work for the British as well as the US Trident programme.

The 12-hourly weather messages produced in the US and fed into the FCS on British Trident submarines could conceivably be used to control the use of British missiles. These messages could be used to send covert on/off signals to the computers on Royal Navy submarines.

BALPARs are approximations. Because of bandwidth limitations, more detailed weather data is not transmitted for the target areas in OPLAN 8044. However if the US was planning to use a limited number of warheads in a non-Russian situation, then it is likely that they would send more complete weather data, including wind speed and air density at different altitudes. This could increase accuracy by approximately 25 metres. NSWCDD have been working on how to improve weather data for US and British submarines as part of the SLBM Retargeting System (SRS). If a British Trident missile was used in a limited nuclear attack, then it is likely that specific weather data would be produced and transmitted. Normally this data is created in the US.

Gravity

The earth's gravity field is not spherical but has a pear shape. This affects the trajectory of Trident missiles and RVs. In order to accurately predict gravitational effects, the FCS computer uses a model of gravity over the projected trajectories.

In addition to using sophisticated models of large-scale gravity, Trident also uses information on local gravity in order to increase accuracy. The two effects which are calculated are gravity anomalies, changes in the strength of the gravitational force, and Vertical Deflections, changes in the direction of the force. Detailed gravitational information has been compiled for trajectories for targets in Russia. The ability to construct similar data for other trajectories is limited by the extent of survey work which has been carried out.

In addition to the direct effect of gravity on the flight path of missiles and RVs, gravity also has an important effect on EGNS, the system used to determine the submarine's position, and on the missile's guidance system. Both EGNS and missile guidance use accelerometers to measure velocity. Accelerometers can interpret gravity Vertical Deflection as a change in velocity. In the case of EGNS this can result in an error in the calculation of the submarine's position. In the case of missile guidance it can reduce accuracy.

The FCS computers on Trident submarines carry detailed gravitational data for the patrol area. Vertical Deflection is extrapolated from specially constructed bathymetric databases. This vital information is only available for those areas surveyed in detail and this restricts where submarines can patrol: "Operational areas have always been limited by the requirements of a high-quality Ocean Survey Program (OSP) gravity map".[66]

Less detailed geodetic and gravitational data for the whole of each planned trajectory will also be held within the FCS computers. Lunar information may also be used to anticipate the effect of the moon's gravity on the trajectory of Trident RVs.[67]

Bathymetry

Bathymetry is the science of measuring the depth of the sea. It is crucial to Trident operations, primarily because it provides gravity data, but also because it can be used to provide a bathymetric fix of the vessels position. Only a small proportion of the world's oceans have been mapped in detail. With current ship-based methods it would take 200 years to map the entire ocean bed and even longer to map all coastal areas.[68]

Under the Ocean Survey Program (OSP) the US Navy has surveyed small areas in detail to support Polaris and Trident submarine operations. The information from these surveys is held on the Digital Bathymetric Data Base 0.1 Minute (DBDB 0.1).[69] DBDB 0.1 contains a depth figure for each 0.1 minute segment, latitude and longitude. Around Britain this is equivalent to a rectangle of approximately 100 metres by 185 metres. The depth figure given for each rectangle is accurate to within 9 metres. This bathymetric data is the base from which detailed gravitational data is extrapolated.

Information on which areas have been surveyed in detail is classified secret, as nuclear-armed submarines only patrol within these zones. Extracts from the database can be provided by NSWCDD to submarines in either tape or CD form. These tapes and CDs are all classified at least Secret and some have the highest classification, Top Secret Special Compartmented Information.

Surveys will have been carried out in areas where Polaris submarines have patrolled in the past, as well as where Trident patrols are carried out today. This will include not only parts of the Pacific and North Atlantic, but also areas of the Mediterranean that were used by Polaris submarines based in Spain.

Oceanographers would like to use satellites to produce maps of the seabed based on variations in the height of the sea's surface. The US Navy has in the past pursued this approach and is particularly interested in it today. Trident submarines only patrol within the areas surveyed by the OSP. The Navy would like to use satellite based mapping to enable Trident submarines to launch missiles from other parts of the oceans. This project is called Broad Ocean Bathymetry (BOB).

As part of the BOB programme, Northrop Grumman are producing a computer simulation to measure how accurate Trident would be if the bathymetric data was based on BOB rather than on OSP surveys. In 2002 a presentation on this project showed that the intention was to develop a "go anywhere and shoot" capability for Trident.[70]

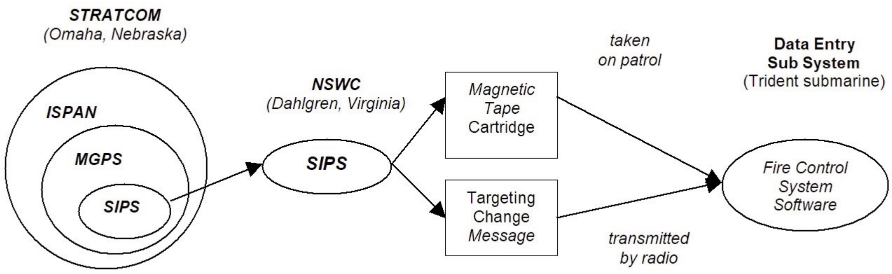
In Britain the MoD's hydrographic survey office produces special detailed material to support nuclear submarine operations. The survey ship, HMS Scott, has equipment designed to produce data in a format compatible with US systems. It is possible that British submarines patrol in zones surveyed by the Royal Navy. It is also possible that the special survey data is shared with the US, in which case the US may provide some of this vital information.

Ripple launch

The FCS software can calculate how to attack a single target with one RV on one missile. However it is designed to calculate the trajectories for a strike using all the missiles and all the RVs on a submarine. In a multiple attack there would be a ripple launch of all the missiles within around 10 minutes. The Fire Control software performs all the calculations for a multiple launch.

Tape and Message Production

The ISPAN system at Omaha uses MGPS and SIPS to produce the basic targeting data for the components of nuclear plans which involve US Trident submarines. This data is then passed to NSWC at Dahlgren for "processing and validation".[71] This involves producing detailed instructions for the FCS on the submarine, using SIPS. The data is produced in two formats: tapes and messages.[72]



Data for attacking pre-planned targets, in OPLAN 8044, is formatted onto 4mm tapes called SLBM Magnetic Tape Cartridges (MTCs). MTCs are produced in the SLBM Weapons Control Facility at NSWCDD.[73] This work is done by EG&G, the main Trident contractor at NSWCDD. EG&G also check the quality of the magnetic tapes.[74] After the MTCs have been checked they are delivered to Trident submarines.

There are several references to contracts for the SCSI Media Generation System (SMGS) for Trident. SCSI is a computer standard that applies to disks and tapes.[75] The production of MTC targeting tapes is described as "media generation". It is likely that SMGS is the system used to produce the tapes at Dahlgren.[76] The contract references are to revisions of SMGS. In May 2001 a contract was sought for Revision 18 to UK SMGS.[77] This suggests that the British target planning centre, NOTC, uses US software to format the target tapes for Trident.

New target data can also be produced at short notice either to attack specific targets or to respond to the changing situation in a strategic nuclear exchange. These are transmitted to US submarines on patrol in the form of Targeting Change Messages (TCMs). From STRATCOM data, NSWCDD produces the information needed by the submarine FCS to attack these additional targets. Communications with submarines have a limited bandwidth, so the messages are compressed at NSWCDD using software designed for the purpose. The completed TCMs are passed from NSWCDD over the SRS Data Links (SRSDL) system to communication sites from where they are transmitted by radio to submarines.[78] When the compressed message is received on the submarine it is expanded using unique software in the FCS. It is likely that the same software will be used to compress and expand TCMs sent to British submarines.

Notes

1. Some contracts use the abbreviation SRS for Strategic Retargeting System rather than SLBM Retargeting System

2. Kristensen Proliferation of WMD. The date may have been to coincide with the annual SIOP cycle. The new nuclear war plan comes into effect in October each year.

3. Adm J T Mitchell, SSPO, Senate Committee on Armed Services, 103 Congress 1st Session, 11 May 1993, quoted in Kristensen Proliferation of WMD

4. SRS Operational Requirements Document, OR #254-0289, US Navy, SSPO, partially declassified and released under FOIA, 9 February 1996, quoted in H Kristensen, Nuclear Futures, for BASIC.

5. Written Answer from Adam Ingram MP to a question from Angus Robertson MP, House of Commons, Hansard 18 June 2004.

6. W Arkin, The Six Hundred Million Dollar Mouse, Bulletin of Atomic Scientists, Nov/Dec 1996

7. Software and Support N00178-99-Q-0020 Commerce Business Daily 24 August 1999. Upgrade of MathWorks MathLab on DGSNET.

8. Software and Support N00178-97-Q-0184 Commerce Business Daily 4 August 1997

9. ibid

10. Information on Seaport team activities conducted by EG&G described by Mountain States Information Systems.

12. Summary of 4 year contract for SCE support from FY 2001,

12. Computer Operational Support for SLBM SCE N00178-05-Q-1926 ;

13. Software and support contract for FCS Commerce Business Daily 4 June 1997

14. D Dwyer,SSP, A Rich Heritage of Naval Innovation, in Navy League of the US

15. Trident II Fire Control Procedures and Operational Support, Commerce Business Daily, 9 April 1999

16. Written Answer from Adam Ingram MP to a question from Angus Robertson MP, House of Commons, Hansard 18 June 2004.

17. K-Technical Support, FBO, 25 January 2003

18. Written Answer from Adam Ingram MP to a question from Angus Robertson MP, House of Commons, Hansard 18 June 2004.

19. Breakdown of costs of modifying two Ohio class submarines from C4 to D5; Trident II (D5) backfit of SSBN 730 and SSBN 731, FY 2004 budget, 1711 Shipbuilding & conversion, Navy/BA2 – Other warships / 211100; February 2003.

20. E Augustus Cooper and A Lee Philpott Jr, Developing software for a distributed, synchronised,

real-time system, , Naval Surface Warfare Centre Dalhgren Technical Digest 1997.

21. A job description for FCS work at K Dept NSWCDD in September 2004 referred to the evaluation of magneto-optical drives and cartridges, hard drives and magnetic tape media. www.egginc.com

22. Information on Seaport team activities conducted by EG&G described by Mountain States Information Systems.

23. Presolicitation, 5 November 2003

24. Description of GDDS work on Trident software, Consortium provides General Dynamics with systems and software infrastructure, Consortium Quarterly, April 2000.

25. Solicitations listed in Commerce Business Daily referring to these programs.

26. Contracts were issued in 2002 for land-based testing of US 640 software.

27. Software with 38 as the last two digits was tested over an FDDI network, which is used on the Mk 98 Mod 4/5 FCS. There is a reference to UK 538 and a parallel reference to US 638. This suggests that 500 software is for the UK and 600 software is for the US.

28. CACI News Release 10 May 2002

29. Written Answer from Adam Ingram MP to a question from Angus Robertson MP, House of Commons, Hansard 18 June 2004.

30. FBM Fire Control MoD 4/5 Software, presolicitation, N0003004G0046NJ16, posted 6 December 2004

31. FY05 Mod 5 UK Intent Word Displays, Award N00030002G0054NJ72, 20 April 2005, for $216,638.

32. Current K Dept M&S Efforts, T Gemmill, Navsea Dahlgren, 30 Nov 99

33. Solicitation for Multimedia training for SIPS, Commerce Business Daily, 7 April 1995.

34. Non Joint Owned Models and Simulations used by Joint Components, Joint Staff, J-8/SAMD, excel spreadsheet

35. ibid

36. Non Joint Owned Models and Simulations used by Joint Components, Joint Staff, J-8/SAMD, excel spreadsheet

37. T Gemmill, Current K Dept M&S Efforts, Navsea Dahlgren, 30 Nov 99

38. SATS is associated with SIMON, which is the version of the SIOP used on the airborne command post. Joint-owned M&S Used by Joint Components, 10 March 1997. SATS is also listed in the legacy progras used in nuclear war planning, Statement of Work for SWPS, Solicitation F25600-02-R-0037, Project USSTRATCOM J6341, 13 March 2003.

39. T Gemmill, Current K Dept M&S Efforts, Navsea Dahlgren, 30 Nov 99

40. Geologics website

41. Current K Dept M&S efforts, T Gemmill, NSWCDD, 20 Nov 99. The trajectory model is referred to as Eclectic6D. The accuracy model may be that described in John Hopkins APL Technical Digest Vol 17, No 4 (1996).

42. Integrating models using an XML database, Todd Wanta, Northrop Grumman; SWS Modelling and Simulation Symposium October 2002.

43. Modelling and Simulation for a "Go anywhere and shoot" capability for Trident II, 30 October 2002, SWS Modelling and Simulation Symposium, October 2002

44. Advance Notice Dahlgren, Software Engineering, Analysis, Research, Development, Test and Engineering Support – Statement of Work for K Department omnibus, 18 July 2005

45. There are four gas generator cylinders and eight nozzles on the PBV, four of the nozzles point aft and four point forward.

46. The diagram below is from Dan Bush et al Trident II D5 Missile Solid Model, 2002 SWS Modelling & Simulation Symposium. On a real PBV the RVs are pointed more towards the centre than shown.

47. Strategic Systems Fire Control, Computing and Mathematical Modelling, NSWC Dahlgren, 1995.

48. Risk Mitigation with Tailored System Testing Following Subsystem Modification Bryant D Palmquist, JHU APL.

49. Ibid

50. NSS has three modes: velocity, depth and ready. The meaning of the third mode is not clear. Lockheed Martin Navigation Simulators; SWS Modelling and Simulation Symposium October 2002.

51. Modelling MIRV footprint constraints in the Weapons Assignment Model, Major Elliot T Fair USAF, Thesis, Air Force Institute of Technology, March 1997.

52. ibid

53. This assumes that the minimum range of Trident is twice that of Poseidon. Poseidon used thrust termination, shutting off power to the PBV, to reduce range. If this is not used on Trident then the minimum range may be greater.

54. SM Davis and DL Owen, FREE – Algorithm for solution of an SLBM multiple constraint mission problem, NSWCDD Technical Digest 1997

55. J F Garcia, Abstract of Impact of Nuclear Weapons Effects on Mission Planning, NWSC, www.mors.org/publications/abstracts/71morss/wg1_abs.htm

56. FREE – Algorith for solution of an SLBM multiple constraint mission problem, SM Davis and DL Owen, NSWCDD Technical Digest 1997

57. Robert Aldridge, US Trident submarine and missile system, the ultimate first strike weapon, Pacific Life Research Center, 2002.

58. Abstract of Accelerometer input axis angular acceleration sensitivity, SP Kau et al, Honeywell Inc, 2000. IEEE Xplore.

59. Since 1977 Honeywell have been designing Inertial Measurement Units for use on Reentry Vehicles with a view to increasing their accuracy. Abstract of ICBM reentry vehicle navigation system development at Honeywell, J Boutelle et al, Honewell Inc, 1998. IEEE Xplore.

60. SP Kau et al, Abstract of Accelerometer input axis angular acceleration sensitivity, Honeywell Inc, 2000. IEEE Xplore.

61. Contract N00030-99-G-0039 FY 99 US/UK BOA definitive CPFF proposal. Commerce Business Daily 1 May 2001.

62. Contract N00030-03-C-0030

63. Wind Tunnel Testing of Strategic Systems in NSWCDD's Tunnel, NSWCDD Technical Digest 1997

64. KA Wright, Computation of Ballistic Parameters for SLBM, NSWCDD Technical Digest 1997

65. Sutherland op cit

66. Modelling and Simulation for a "Go anywhere and shoot" capability for Trident II, 30 October 2002, SWS Modelling and Simulation Symposium.

67. Lunar gravity could result in a 100 m error in Trident accuracy. FK Lamb, Missiles, Physics Lectures, http://wug.physics.uiuc.edu/courses/phys180/spring98/lectures/10/slide11.html

68. Walter HF Smith, Conventional bathymetry, bathymetry from space and geodetic altimetry, Oceanography Vol 17 No 1 2004.

69. Military Specification for Digital Bathymetric Data Base 0.1 minute and Digital Bathymetric Database 0.5 minute. Mil-D-89029 (Navy), US Defence Mapping Agency.

70. Modelling and Simulation for a "Go anywhere and shoot" capability for Trident II, 30 October 2002, SWS Modeling and Simulation Symposium.

71. Information on Seaport team activities conducted by EG&G described by Mountain States Information Systems.

72. One illustration indicates that SIPS is used to produce tapes and messages and another indicates that NSWCDD produces target tapes; T Gemmill, Current K Dept M&S Efforts, Navsea Dahlgren, 30 Nov 99

73. Description of work of the SLBM Weapons Control Facility at Dahlgren http://scitechweb/inhousereport00navy/00nswc.html

74. Information on Seaport team activities conducted by EG&G described by Mountain States Information Systems; EG&G Job Vacancy Announcement for Engineer to test tapes and drives, www.egginc.com

75. SCSI – Small Computer Serial Interface

76. SMGS may also produce other data for the fire control system, such as geodetic and gravity information.

77. The solicitation summary says "Software Media Generation System", but this is probably a misprint for "SCSI Media Generation System". Misuse of abbreviations is common in contract summaries. K-Trident FBM Fire Control Rev 18 to UK Software, 10 May 2001. Sol N00030-98-G-0051-NJ96.

78. SRSDL transfers classified data between NSWCDD and remote/alternative sites; Data/STE terminal solicitation, Commerce Business Daily, 7 February 2000, N00178-00-Q-1021

Annex G
Communications to British Trident

Extremely Low Frequency (ELF)

The US Navy used to operate an ELF transmitter to communicate to its Trident submarines. ELF could send very basic messages which could be received by a submarine at considerable depth. The system is no longer operational. In the early days of the British Trident program there was a plan to build an ELF transmitter at Glengarry in the Scottish Highlands, but this was never implemented. The government has said that Royal Navy submarines cannot receive ELF signals.

Very Low Frequency (VLF) and Low Frequency (LF)

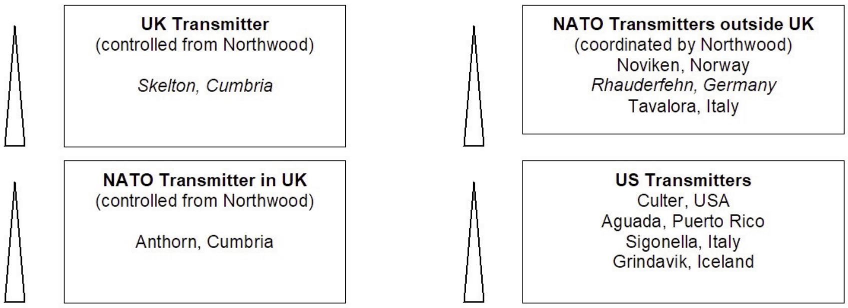
VLF/LF has been described as "the backbone of the submarine broadcast system".[1] A submarine can receive signals on these frequencies without having to raise an antenna above the surface. VLF/LF radio messages can be sent to British submarines using British, NATO or US transmitters.

For decades Britain operated VLF transmitters at Rugby and Criggion. However both transmitters closed down on 31st March 2003. The Alert Consortium under a contract issued in 2001 now provides VLF communications. Alert have replaced Rugby and Criggion with a new VLF transmitter at Skelton, near Penrith. The same site is used for commercial High Frequency broadcasts including the BBC World Service. Skelton is operated by Merlin Communications, part of the Alert Consortium. The new transmitter is probably the primary means of communicating with British Trident submarines. Merlin Communications will also provide new VLF receivers for British submarines.

NATO also operates a network of VLF transmitters. The NATO submarine commander based at Northwood has control over the VLF transmitter at Anthorn in Cumbria. He also coordinates three other transmitters in Norway, Germany and Italy. These transmitters were working in a mode which provided four channels from each, although this may have changed. Anthorn is now operated by Merlin Communications and is being upgraded as part of the contract awarded in 2001.

The US also has a network of VLF/LF transmitters covering the North Atlantic. The main VLF transmitter is at Culter in the USA. There are also LF transmitters in Iceland, Puerto Rico and Italy. These provide the main line of communications with US Navy Trident submarines in the Atlantic.

VLF/LF Communications to UK Trident



In 1988 the US initiated the NATO Interoperable Submarine Broadcast System (NISBS). NISBS enables NATO to use VLF/LF transmitters operated by the US around the Atlantic. A message from Britain could be transmitted to a British submarine using US transmitters in America, Puerto Rico, Iceland or Italy. NISBS also enables the US to use NATO's four VLF transmitters. A message from the US Submarine Commander can be broadcast to a British submarine either using the American transmitters or any of the NATO transmitters in Europe.

The US transmitters were modified so that one of the four channels used by each transmitter was compatible with NATO. There is ongoing development of NISBS. In 2002 a contract was issued in the US for a further upgrade of the system.

In addition to sending messages to NATO vessels the US can also make bilateral, US/UK, submarine broadcasts.[2] The Broadcast Control Authority (BCA) for these bilateral broadcasts is the Commander Submarine Group 10 at Kings Bay, Georgia. The bilateral system allows the US Trident commander at Kings Bay to communicate directly with British Trident submarines.

In the early days Morse code was used in VHF/LF broadcasts to submarines. Later a method of transmitting data over VHF/LF was devised. This is called the VHF Digital Information Network (VERDIN) and is used by both British and American Navies. VERDIN has been modified to provide compatibility with NATO and has been upgraded to the Enhanced Verdin System (EVS).

Michael Clarke suggests that the reduction in the alert status of Trident, implemented in 1998, involved a change in communications procedures – "boat commanders would be in less frequent touch with their base as a matter of normal operating procedures".[3]

UHF/SHF Satellite Communications

Submarines can raise an antenna to communicate with satellites. To avoid detection the antenna is raised for only a few minutes. Data transfer to submarines, even by satellite, has in the past been slow. Since 1995 the US has been increasing the bandwith available for satellite communications with submarines. This reduces the time needed to transfer data and so allows substantial volumes of information to be exchanged without raising the antenna for long. In 2001 it was clear that British submarine communications were still limited by the low bandwith available.[4]

British submarines have access to US, NATO and British satellite communications systems. Britain deploys three satellites to provide military communications. The initial batch of Skynet 4 satellites (A, B and C) were deployed between 1988 and1990.[5] These were replaced between 1998 and 2001 by the second batch of Skynet 4 (D, E and F) that are currently in service. These each have three SHF transponders and two UHF transponders.[6] France and Germany are also involved in the Skynet system. In addition there is a NATO satellite, NATO IV. This is based on Skynet 4 and provides communications over the Atlantic and Europe.[7]

The MoD has awarded a £2.5 billion Private Finance Initiative contract to replace Skynet 4 with Skynet 5. There will be two satellites, one over the Atlantic and one over the Indian Ocean. These are due to be launched in 2006 and 2007 and would provide SHF and UHF communications.

Submarine communications using UHF on Skynet and NATO IV are compatible with the US FLTSATCOM satellite system using a Demand Assigned Multiple Access (DAMA) antenna. SHF communications on Skynet and NATO IV are compatible with the US Defence Satellite Communications System (DSCS).

Control of Skynet 4 and NATO IV is from RAF Oakhanger (NATO designation F4). The other NATO satellite ground stations in Britain are at Balado Bridge (F17) near Kinross and at Saxa Vord (F29) in Shetland. Skynet 5 will be controlled from RAF Colerne, in Wiltshire.

There is a current British project to replace existing UHF DAMA antenna on submarines with a new Sub DAMA Satellite Communications System (SDSCS). As part of this, new mini-DAMA are being bought from the US. These will probably be able to handle data at higher rates of transmission. There is also a program to develop a new Universal Modem System (UMS) for handling satellite data on a submarine. UMS should provide compatibility between US, British, French and NATO systems.

Satellite Communications to UK Trident

British/French/German Satellite System	NATO Satellite System	US Satellite Systems
Skynet 4 (UHF &SHF) To be replaced by Skynet 5 (UHF & SHF)	NATO IV (UHF & SHF)	FLTSATCOM (UHF) *DSCS (SHF)* In future: MILSATCOM (EHF)

EHF Satellite Communications

In 1997 the US Air Force began a project to upgrade communications to their land-based ICBM. The specifications for this show that the US does not regard the UHF/SHF satellite communication system as reliable during a nuclear conflict. The satellites could be seriously affected by nuclear weapons detonated at very high altitude. So the existing system is being supplemented by an Extremely High Frequency (EHF) satellite communications system. This would be expected to continue to operate during a nuclear war. The new system is considered to be critical: "Improved EHF communications remains a key to providing survivable communications to strategic nuclear forces."[8]

The US Navy is improving communications to its submarines. This includes adding a new EHF satellite system. This EHF facility is regarded as the most important communications project for Trident.[9]

The MoD was considering adding an EHF facility onto Skynet 5 but is now advocating that Britain join in the US Advanced EHF (AEHF) MILSATCOM satellite programme. So Britain will be dependent on the use of US satellites for EHF communications. New shore-based terminals will be set up as part of the Naval EHF/SHF SATCOM Terminal (NEST) project. NEST will provide "robust, high data rate satellite communications to UK submarines".[10]

In addition to being able to operate through a nuclear war, EHF also allows the transfer of a larger volume of information, including retargeting data. EHF is a critical part of future communications to US Trident submarines, and may become critical for British operations. British EHF communications will be dependent on the use of an American satellite.

Data handling protocols

Until recently the US Navy communicated with its submarines using the Submarine Satellite Information exchange Sub-system (SSIXS). SSIXS prepared messages for both VLF and satellite broadcast. The Royal Navy was also using SSIXS, and the British and American systems were compatible. In 2003 the US Navy moved from SSIXS to an Internet Protocol (IP) system.

A briefing given to a joint maritime communications group by a British official in 2001 indicates that this change was not expected. It was important that British submarines continued to have access to US communications.[11] In 2001 two joint working groups were established. Both were to investigate how to provide compatibility with the new IP system. The first was a US/UK working group. Following requests from Australia and Canada, an additional Allied working group was also set up.

Within Britain, the MoD initiated the Submarine Command and Control (SMC2) project to deal with the problem. The SMC2 programme is "responsible for maintaining UK/US interoperability capability by migrating the Royal Naval Submarine Satellite Information Exchange System to an Internet Protocol environment".[12]

Cryptography

US submarines carry a range of encrypting and decrypting equipment. The NATO interoperable system requires common crypto equipment. The US change to an IP protocol has created additional problems in this area. It is likely that there will be bilateral, US/UK, crypto equipment to support Trident operations.

Notes

1. Submarine Communications Master Plan, December 1995, Appendix B
2. Software Development Pland for NISBS, October 1999, Space & Naval Warfare Systems Centre, San Diego.
3. M Clarke op cit
4. Sutherland op cit
5. Skynet 4 A, b & C deployed at 326 degrees West, 53 degrees East and 1 degree West
6. SNF transponders have a power of 50 watts and a frequency range of 60 – 125 MHz
7. Federation of American Scientists
8. EHF capability for ICBM LCCs, Operational Requirements Document, April 1997, USAF.
9. Submarine Communications Master Plan, December 1995 www.fas.org
10. Satellite Communications Acquisition IPT
11. Sutherland op cit
12. Satellite Communications Acquisition IPT www.mod.uk

Annex H
Modes of use of Trident

A minority of British Trident missiles are now allocated a "sub-strategic" role. However when comparing British and American practice the term "sub-strategic" is misleading. The US has mechanisms for using strategic Trident missiles in support of theatre operations. In practical terms there are two ways in which Trident can be used. It can be used as originally designed, with all the warheads on a submarine being used at once. Alternatively a small number of warheads can be used in an attack. Because of the difficulties created by the terminology, these are described here as Mode One and Mode Two.

Mode One - Using all the warheads on a submarine

The reason that long-range nuclear-armed missiles are deployed on submarines is because their location can be concealed. Land-based missiles are likely to be targeted in the early stages of a nuclear exchange. Airfields for nuclear bombers are equally vulnerable. Trident submarines are regarded as being invulnerable up until the point when they fire a missile. When a missile is fired the submarine's position is revealed. It then becomes very vulnerable, not only to a nuclear strike, but also to an attack from the opponent's hunter-killer submarines and surface ships. Trident submarines were designed so that to launch all the missiles could be launched in as short a time as possible, probably around 10 minutes. Most US nuclear plans will involve all the missiles on a particular submarine being launched at the same time.

A few submarines, the Secure Reserve Force, would not be used at the start of a strategic nuclear war. They would be held back till the final phase. The targets for the Secure Reserve Force may be altered as a nuclear conflict unfolds. Control is exercised through the US Airborne nuclear command aircraft. These have special systems for controlling and retargeting Trident.[1]

The process of allocating targets to US nuclear weapons is very complex. For the sake of simplicity it is likely that all the US Trident missiles carry the same number of warheads. The evidence suggests that until July 1998 British submarines on patrol carried 12 armed missiles, each with 5 warheads. After the Defence Review it is likely that the loading was reduced to 12 missiles with 4 warheads on each.[2]

Mode Two - Using a small number of warheads

Mode Two is used here to describe a variety of ways in which Trident can be used, which are not covered by Mode One. This includes one missile on one warhead. It also includes launching a small number of missiles with single or multiple warheads. It could potentially involve deploying a lower-yield warhead.

Mode Two - US

The SLBM Retargeting System (SRS), which became fully operational in 2003, allows the US Navy to rapidly retarget Trident missiles so they can be used in a limited nuclear strike. The US nuclear planning system has also becoming more integrated – both between strategic and theatre plans, and across weapon systems. There are now mechanisms in place to rapidly produce a nuclear attack plan for using a small number of Trident warheads in a regional operation. The targeting data could be produced quickly and communicated to the submarine.

The draft Doctrine for Joint Nuclear Operations described how nuclear weapons may be employed in a regional setting, particularly against WMD targets.[3] It is clear that nuclear weapons of all types could be made available to the US Commander in a region of the world. The draft Doctrine compared the different types of weapons in the arsenal and it lists the advantages and disadvantages of Trident compared with other nuclear weapons.[4] It says that there are both advantages and disadvantages of using missiles with their normal multiple warhead (MIRV) configuration.

One of the main disadvantages is that the missiles would have to be released from OPLAN 8044 assignment. If one or two Trident missiles are launched in a limited nuclear strike, it is not only those missiles which are no longer available for use against Russia, but all of the missiles on the submarine. The launch would compromise the vessel's position and it would become a prime target in a full-scale nuclear exchange. It would be possible to get round this by deploying an extra submarine.

Calculating Russia's response presents a dilemma for nuclear planners. If they launch a missile at a "wider threat" target and do not inform Russia in advance, then Russia may misinterpret this as a strike against itself.[5] However if the Russian leadership were given several hours notice, how would they respond? Faced with a potential nuclear strike at a third country, Russia might decide to increase the state of alert of their strategic nuclear forces. Russian and non-Russian roles for nuclear weapons are connected. The potential for escalation is a major factor for the nuclear planners. Over the decades STRATCOM has conducted many wargames which have simulated how a regional conflict can lead to global nuclear war.

Paul Robinson, Chair of the Strategic Advisory Group accepts that the use of land-based ICBMs in a limited role could be misinterpreted as an attack on Russia. However he argues that this need not be the case with Trident as a submarine could be moved around the world so that its flight path was not over Russia. But the risk that a launch will be detected and misinterpreted cannot be eliminated.

Mr Robinson has also proposed that some Trident missiles should be armed with single warheads.[6] He considers that these would be particularly suited for non-Russian roles. There has been no sign that this suggestion has been implemented. A US limited nuclear strike is more likely to be carried out using B2 bombers than Trident.

Mode Two - UK

In 1993 Malcolm Rifkind announced that when the WE177 nuclear bomb was retired it would be replaced, not with the Tactical Surface to Air Missile (TASM), but with a small number of Trident missiles, reconfigured for a Sub-Strategic role. Each of these missiles would carry a single warhead. When Rifkind made this announcement it was also said that WE177 would remain in service until 2007.[7] However the bombs were withdrawn from service early, by 1998, and sub-strategic Trident was introduced more quickly than planned. Sub-strategic Trident has been assigned to NATO, and has inherited the role allocated to WE177. It is part of the sub-strategic nuclear forces of NATO.

A British submarine firing one or two Trident missiles would compromise its position and role against Russia. The Commander of the submarine squadron at Faslane has said that for a sub-strategic mission he might use, not the submarine on patrol, but a second vessel.[8] The MoD said that Sub-Strategic Trident would only be fully robust when there were three operational Trident submarines. For all these reasons the Sub-Strategic role is probably allocated to one of the two submarines not on patrol.

The alert status of Sub-Strategic Trident is not clear. The other NATO's Sub-Strategic nuclear forces, Dual Capable Aircraft, are now on a state of readiness measured in months. When Sub-Strategic replaced WE-177, the aircraft that would have dropped these bombs were on an alert state measured in weeks and months. It is possible that the alert status for Sub-Strategic Trident is significantly lower than the several-days notice of the strategic force. If it is regarded as a supplement to the US Global Strike force then a higher state of alert is likely.

The American SRS system has recently been installed on British submarines. This allows missiles to be rapidly retargeted at new targets which have been transmitted from shore. This will be a vital part of the sub-strategic Trident system.

The Defence Committee was told in March 1994 that before Trident was used Britain would communicate clearly its intentions, and that this was particularly relevant for any use of Trident in a sub-strategic role. The dilemma of whether or not to give Russia advance notice of the use of Trident against a third country, would apply to British missiles.

Lower yield

The draft US Doctrine for Joint Nuclear Operations lists one of the disadvantages of the use of Trident in a Theater operation as being that it has too large a yield for some missions. Weapons with too high a yield have been described as "self-deterring". A threat to use them is not credible, because the destruction they would cause would be so disproportionate.

It is almost certainly the case that the MoD considers that the deterrent effect of Trident would be greater if there was a suggestion that some missiles have a lower-yield warhead. The most explicit statement of this was George Robertson's reply to a question on the yield of sub-strategic Trident. Mr Robertson said: "The UK has some flexibility in the choice of yield for the warheads on its Trident missiles".[9] This falls short of saying that lower-yield warheads are in service. The statement might mean that Britain could, if it wished, deploy a version of Trident with a lower yield. There is little doubt that this is true. A lower-yield warhead could be designed and deployed. But has it?

In 1994 the Defence Committee questioned MoD officials on sub-strategic Trident. The replies show that the only projected expenditure on sub-strategic Trident was on the shore-based target planning system.[10] There would be no expenditure on warheads – "No additional warhead costs will be incurred on account of the sub-strategic role."[11] These remarks suggest that in 1994 it was not anticipated that a lower-yield warhead would be produced.

The comments Rear Admiral Irwin made to the Committee are very similar to the approach to Theatre use of Trident in US policy. He said: "There is no such thing as a tactical or strategic missile; it is the use to which you put it".[12] He also said that a missile with a single warhead could be used in either a strategic or a sub-strategic attack.

The W76 warhead can destroy moderately hard targets, but for more hardened bunkers and missile silos two or more warheads would be aimed at the same target. A lower yield Trident warhead could devastate industrial or urban targets, but would not destroy silos or bunkers. While a lower-yield warhead may be less “self-deterring”, it would only be able to destroy a narrower range of targets than the existing 100-kiloton version.

A fixed lower yield could be achieved by replacing the thermonuclear part of the warhead with a dummy. Paul Robinson suggested that the US should do this with some Trident warheads.[13] There is no sign that his proposal has been translated into an official project. It is possible that Britain may have modified some warheads in this way, but this is by no means certain.

Accuracy

If Trident were made more accurate, then a lower-yield warhead would be able to destroy a wide variety of targets, including substantial bunkers. For decades Lockheed Martin has been trying to develop more accurate RVs for submarine-launched missiles.[14] One design would add flaps to the aft end of the RV and to use these for manoeuvring. The flaps would be exposed to very high temperature. A GPS receiver would be used to monitor the RV’s position.[15] However the GPS signal is lost during re-entry. Inertial guidance would then be crucial. Small inertial guidance units are being developed to provide telemetry information for RVs used for Trident test flights. This guidance technology could later be incorporated into armed RVs.

In January 2003 Lockheed Martin lodged a patent for a Manoeuvrable Re-entry Vehicle (MARV).[16] This used flaps and had an initial flight-test in October 2002. The project was adopted in the US Defence Budget for Financial Year (FY) 2004 as Enhanced Effectiveness (E2).[17] Funding was allocated to develop and test this MARV over three years.[18] In May 2003 a contract was going to be placed with Charles Stark Draper Laboratory for evaluating GPS and inertial guidance units for the MARV.[19] However the FY 2005 budget shows that Congress withdrew all funding for E2.[20] There was no attempt to reintroduce it in the FY2006 budget.[21]

A report produced by Lockheed Martin in 1997 describes how a Trident RV could be modified so that it could be used as a conventionally-armed earth penetrator.[22] For this role the RV would have to descend at an angle close to perpendicular to the earth’s surface. This would be steeper than any ballistic trajectory. The solution proposed was to add flaps to alter the trajectory of the RV. These flaps would also have to reduce the velocity of the RV. The design was for a conventional, not a nuclear, warhead. The warhead has to fit inside the narrow diameter of the earth penetrator. This is too small for a nuclear device.[23] To land close enough to the target to be effective, this proposal would require a substantial increase in accuracy.

In addition to various plans to add flaps to an RV, an alternative design solution has been proposed. This would involve moving a weight inside the RV to change the centre of gravity and so alter the trajectory.[24] Although papers with this idea have been circulated there is no sign of a firm plan to implement this proposal on armed RVs. Tests of this concept, using a Mk4 RV, are being carried out as part of a Missile Defence program to develop manoeuvrable interceptors.

The US budget in FY2004 allocated funds for a Navy research study related to RNEP. This was probably one of Lockheed Martin projects - either the MARV project, which has not been funded in FY2005, or the proposal for a conventionally-armed earth penetrator.

Notes

1. SLBM Adaptive Planning System (SATS) and Direct to Force (DTF). The need to retarget the SRF was probably also a factor driving the SLBM Retargeting System.

2. At this time US Trident missiles probably carried five warheads. In order to implement the decision of the Strategic Defence Review 12 warheads were removed from each Trident submarine in 1998. While the first Trident submarine, HMS Vanguard, collected 16 missiles from Kings Bay, the second only picked up 12 missiles.

3. Doctrine for Joint Nuclear Operations, Joint Publication 3-12, 2003

4. Advantages: No risk to crew, Can be launched in international waters, Has a short flight time, Stealth and surprise can be achieved prior to launch, Flexible targeting capability. Disadvantages: Yield may be too large, Cannot be recalled once launched, Must be released from its SIOP commitment. Doctrine for Joint Nuclear Operations Joint Publication 3-12, 2003; Multiple warheads present “more planning challenges”, but they could be considered suitable for using against a target which was spread out over a large area. Doctrine for Joint Theater Nuclear Operations, Joint Publication 3-12.1, 9 February 1996

5. The early draft of the Doctrine for Joint Nuclear Operations highlighted concern about missile flight paths crossing the territory of nuclear powers, and the likelihood of them responding. The reference to nuclear powers was then deleted and the paragraph altered to a general reference to the airspace rights of all nations. Joint Staff Input to the Doctrine for Joint Nuclear Operations, JP 3-12, 28 March 2003.

6. Robinson White Paper

7. In 1992 the retirement date for WE-177 was 2000. In 1994 it was given as 2007. Progress of Trident, House of Commons Defence Committee, HC297, 1994 p xviii

8. Commander Tom Herman, 1 Submarine Squadron, Navy News Clyde Supplement, May 1996.

9. Hansard 19 March 1998 column 724; reply to question from Roseanna Cunningham MP

10. “The money is being spent only on providing facilities ashore”, Rear Admiral Irwin, Progress of the Trident Programme, 2nd Report of the Defence Committee, 1993-94, HC 297, p6

11. Progress of the Trident Programme, 2nd Report of the Defence Committee, 1993-94, HC 297, p26

12. ibid, p6

13. Robinson White Paper. It is also possible to vary the yield of a nuclear weapon by adjusting the voltage in the neutron generator. There is no indication that the new W76 neutron generators can give a variable yield.

14. Robert Aldridge op cit

15. A Hard and Deeply Buried Target Defeat Concept, NF Swinford & DA Kudlick, Lockheed Martin, 1997

16. Lockheed Martin press release 3 June 2003

17. Research and Development, Strategic Sub and Wpns Sys Spt, PE 0101221N, FY2004 budget, Feb 2003, p3-6; Modifications to the Fire Control System for the E2 programme were also proposed – Trident D5 Fire Control solicitation 2 April 2003.

18. This project is also referred to as Enhanced Effectiveness (E2), Statement of Rear Admiral CB Young, Director SSP, before the Strategic Subcommittee of the Senate Armed Services Committee, 8 April 2003

19. N00030-04-C-0007 pre-solicitation from SSP 13 May 2003, FBO

20. Research and Development, Strategic Sub and Wpns Sys Spt, PE 0101221N, FY2005 budget, Feb 2004, p2

21. Research and Development, Strategic Sub and Wpns Sys Spt, PE 0101221N, FY2006 budget,

22. NF Swinford & DA Kudlick, A Hard and Deeply Buried Target Defeat Concept, Lockheed Martin, 1997

23. The conventional warhead on the earth penetrator is 5.5 cm in diameter and 21 cm long, whereas a normal warhead takes up most of the space inside the RV. ibid

24. EJ Regan, Moving Mass Roll Control for Fixed-Trim Reentry Bodies, NSWCDD Technical Digest 1997.

Annex I

US W76 Warhead and UK Trident Re-entry Body

Cautionary note

While technical details of some aspects of Trident warheads are in the public domain, other areas remain secret. In collating this data there is a danger that the relative significance of what is in the public domain may be exaggerated.

The US Department of Energy (DOE), which builds nuclear weapons, is not averse to exaggerating its own problems. In order to obtain more funding they have in the past multiplied the number of warhead anomalies, ignoring the fact that several warheads are based on a small number of common designs. Some individuals within the nuclear weapons establishment may also emphasise design problems in order to lobby for a restart to nuclear testing.

Terminology

The US Department of Energy (DOE) refers to nuclear weapons as warheads. The most common of the two Trident warheads is the W76. The Department of Defense refers to the same weapon as the Mk 4 Re-entry Body (RB). Sometimes the two terms are combined - W76/Mk4. The DOE designation, W76, is used for most of the discussion below.

British nuclear weapons and missiles are given an alphanumeric code.[1] For example, the freefall bombs in service until 1998 were designated WE-177 and the planned RAF replacement was TD-127. There is likely to be a similar code for the Trident warhead, but it is not known. There are official references to the “UK Trident RB” and this term is used here.

Trident warheads

Two types of Trident missile were developed. The earlier C4 missile has now been replaced by the larger D5. The D5 is deployed on British submarines.

Two warheads are used on US Trident:

- The W76 warhead was designed for the C4 missile and has a yield of around 100 kilotons. It was produced in large numbers and is now deployed on D5 missiles.
- The W88 was designed for the D5 missile and has a yield of 475 kilotons.[2]

The UK Trident RB was originally intended for use on the C4 missile and is based on the W76. The British warhead was described by a former director of Los Alamos as a "Dutch copy" of the American design. A Public Records Office report says that the US design was "anglicised" at Aldermaston.[3] Most of the information below refers to the US W76 warhead. This gives a valuable insight into the breakdown of the UK Trident RB. A few specific details of the British warhead are known, other features can be deduced from US data.

The W76 entered service in November 1978.[4] Manufacture of the warheads continued until 1987.[5] Today there are more W76 warheads in the operational US arsenal than any other design of nuclear weapon. It has been described as the most vital part of US nuclear forces. The Los Alamos Laboratory website says, "W76/Mk4 is the most critical element of our nation's strategic deterrent".[6] A US Navy spokesperson said, "The Mk4 Reentry Body is the mainstay of our nation's nuclear deterrent".[7]

Design review

The US carried out a major review of the W76 between 1996 and 1999.[8] By this time the first warheads had been in service for 20 years. In retrospect it was said that this was the planned life of the warhead.[9] The review was a dual revalidation. It involved the warhead's designers, Los Alamos National Laboratory (LANL), and also their rivals, Lawrence Livermore National Laboratory (LLNL). The review revealed: "even though components are aging gracefully, there are some negative changes".[10]

Britain was involved in the W76 dual revalidation. Problems identified during revalidation have implications for the UK Trident RB. In addition Aldermaston has its own timescale for reviewing British warheads. Professor Oxburgh, the Chief Scientific Adviser, wrote a report into the safety of British nuclear warheads. This established a process of regular design checks. In 1994 the Defence Committee was told that the first design review for Trident was taking place and that subsequent reviews would be carried out every 7 years.[11] This suggests that the UK Trident RB design would be reviewed in 2001 and 2008.

Alterations and Modifications

The DOE uses two terms to describe upgrades to nuclear warheads. An Alteration is a smaller change, whereas a Modification is a more substantial revision. Two programmes were initiated to upgrade the W76. The most significant is the W76-1 Modification. W76-1 is currently the most substantial component of the US nuclear weapons programme. Warheads will be rebuilt as W76-1 from 2007 onwards. The original design is now referred to as the W76-0.

The second programme is Alteration (Alt) 317. This upgrade of W76-0 was started during the dual revalidation. Alt 317 replaces the neutron generator and gas transfer system. It appears that the changes made to US warheads under Alt 317 are also being made to British warheads.

W76-1 Overview

A major study into how to extend the life of the W76 warhead was started in October 1998.[12] One major ground rule was that the refurbished warheads should be able to continue in service for 30 more years without a further major overhaul.[13] The study involved Sandia and Los Alamos Laboratories, the Strategic Systems Program, STRATCOM, Lockheed Martin and ITT. The results were presented to the Nuclear Weapons Council in March 2000. The military characteristics of the W76 were a baseline for the W76-1. However the refurbished warhead will provide increased "targeting flexibility and effectiveness".[14]

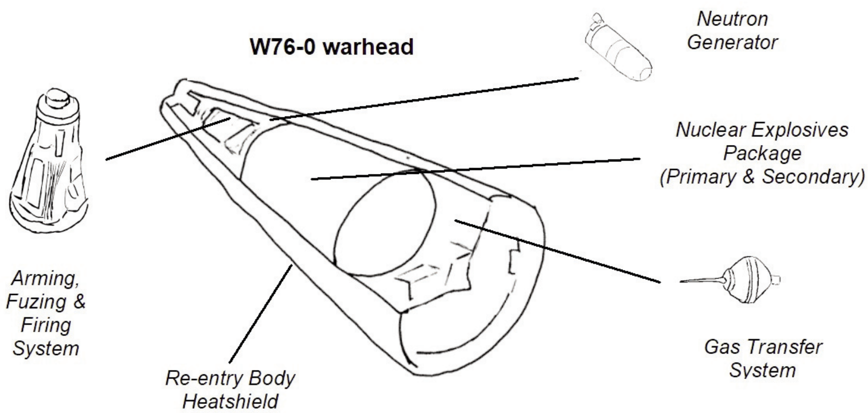
The W76-1 will re-use the Plutonium pit and Highly Enriched Uranium (HEU) secondary in existing warheads but it will be a major refurbishment. A wide range of warhead components will be replaced. It is the most substantial modification of any warhead in the current US programme. As such it is one major factor driving the Advanced Strategic Computing (ASC) initiative. In the absence of nuclear testing, new components are tested by computer simulation.

One strand of ASC is the development of a computerised capability to verify the Stockpile to Target Sequence (STS). In the case of Trident this simulates the environment a warhead could encounter including the stresses of a ballistic trajectory. The W76 is the lead weapon for the part of ASC that deals with testing the STS of non-nuclear components.[15] The lead warhead for developing a detonation simulation was the W80, but the W80 Life Extension project was cancelled in 2006.

While progress is due to be made with computer verification of W76-1 by 2007, this work will not be complete. The development of Qualitative Margins of Uncertainty (QMU) for the W76-1 is not due to be finished until FY2009.[16] The completion of a full-system coupled STS simulation for abnormal environment is scheduled for FY2008 and the equivalent for a hostile environment will be later.[17]

The First Production Unit (FPU) of W76-1 is due to be manufactured in FY2007. Current work is on Block 1. This is a plan to upgrade 40% of the stockpile of W76 warheads.[18] Block 1 should be completed by 2020. The Administration are now considering curtailing the W76-1 upgrade programme and switching to the Reliable Replacement Warhead, which may be available by 2015

In February 2002 the British Government was asked about the W76-1. Defence Minister Dr Moodie said discussions with US counterparts included “work on the US W76 warhead, relevant to the safety and reliability of the UK’s Trident warhead”.[19] In July 2006 the MoD said that a “relatively minor upgrade” of the warhead will be required in the first half of the next decade.[20] Job vacancies at Aldermaston reveal that the UK are about to introduce a new Arming, Fuzing and Firing System, which is at the heart of the W76-1. It is likely that they are planning an upgrade, to a specification similar to W76-1, between 2010 and 2015.



The Primary and Secondary are both within the Nuclear Explosives Package (NEP).[21] In the case of the UK Trident RB, the evidence suggests that all the components outside the NEP are procured from the US. Neutron Generators and the reservoirs within the Gas Transfer System are Limited Life Components and are replaced on a regular basis, at sites where weapons are deployed. This work is done inside the RB process building in Coulport.

Below are sections on each of the following components of the W76 & UK Trident RB:

- Re-entry body heatshield
- Arming, Fuzing and Firing System
- Neutron Generator
- Gas Transfer System
- Radiation case
- Primary
- Secondary

Re-entry Body Heatshield

Lockheed Martin built hardware kits for US and British Mk4 Re-entry Body Assemblies (RBAs). Production started in 1977 and a total of 5,000 RBA kits were built. These kits include the release assembly, which deploys the RB from the Post Boost Vehicle, the heatshield and connectors. Production of the kits ceased in 2000. Lockheed Martin retained the production tooling. Further work is expected as part of the W76-1 life extension programme.[22]

During re-entry the heatshield, which protects the warhead, is worn away by ablation. This affects the aerodynamic performance of the RB and therefore its accuracy. This is particularly a problem with the nose tip. Existing heatshields are made of rayon-based carbon phenolics. This may be changing over time and the rayon is no longer available. A contract was issued to develop alternative heatshield materials for Mk4 and Mk5 RBs between 2004 and 2008.[23]

Arming, Fusing and Firing System

The Arming, Fusing and Firing System (AF&F) controls the detonation of the warhead. In 1994 Inside Energy reported that Paul Robinson of Sandia National Laboratory had said “Sandia also designs the arming-fusing-firing mechanisms for the British nuclear weapons programme”.[24]

The US Department of Energy (DOE) is responsible for nuclear warheads, whereas the Trident missile is within the remit of the US Navy. The AF&F integrates the Navy arming and fusing sub-systems with the DOE firing sub-system.[25] The arming and fusing components on UK Trident RBs are an integral part of the missile system. This missile system was acquired off-the-shelf from the US. The arming and fusing sub-systems are almost certainly not only designed but also built in America. The firing system is probably also procured from the US but might not be.

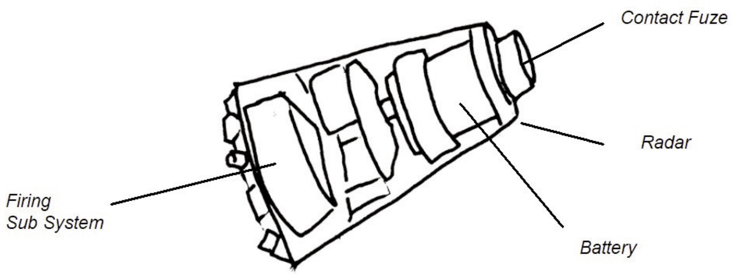
The main interface between US-built and British-built components is probably at the radiation case.

MC2912 AF&F (W76-0)
The MC2912 is the AF&F system currently deployed on US W76-0 warheads. Either MC2912 or a very similar system will be used today on UK Trident RBs. There appear to be concerns about some components of MC2912. Particular attention was paid to the AF&F during dual revalidation. In the course of the review 19 AF&F systems were disassembled and tested. A series of computer models of the MC2912 have been produced with increasing levels of detail.

MC4700 AF&F (W76-1)
The MC4700 is a new AF&F designed for the W76-1.[26] This is a critical element of the new Modification. It will modernise the system so that it is comparable with the AF&F in the W88 warhead. Computer support for the new design has been at the forefront of simulation work within the US nuclear establishment and has been the focus of the High Performance Electrical Modelling and Simulation (HPEMS) effort.

Aldermaston is preparing to support the introduction of a new AF&F into UK Trident.[27] This will be similar to the MC4700.

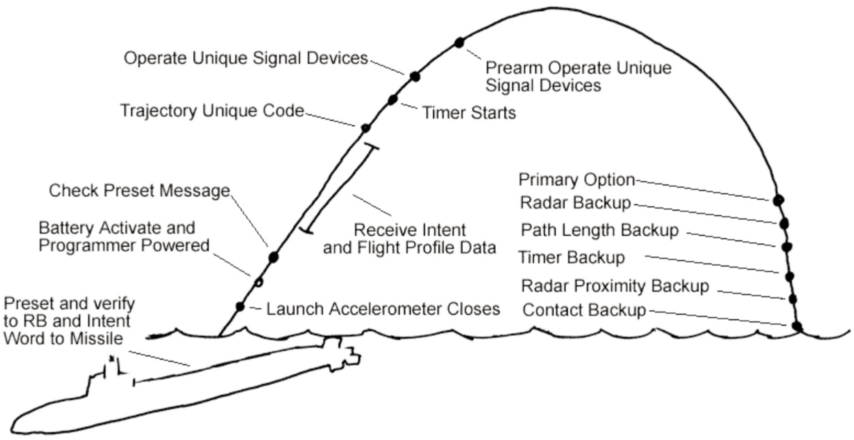
Conceptual Model of MC4700 AF&F



The sections below describe components of both the old MC2912 and the new MC4700

Programmer
At the heart of the AF&F is a programming module. This controls the components of the warhead. The diagram below shows the sequence of actions carried out by the AF&F system in a Trident warhead, possibly the

W88.[28] The MC4700 in the W76-1 is likely to use a similar sequence.



The diagram indicates that flight data is initially conveyed from the Fire Control Computer to the Missile. When the missile is in flight the programmer on each warhead is powered up. The appropriate data is then transferred to each warhead.

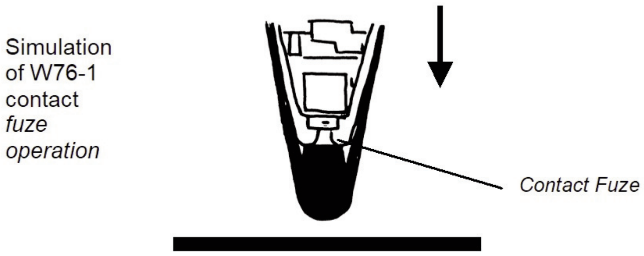
The AF&F prepares the warhead for detonation. The pre-arm functions may include electrical operations and operating the gas transfer system. The programmer also carries out diagnostic checks on warhead components.

The diagram conveys the sequence in which actions are carried out. It suggests roughly where in the trajectory specific event happen. The six points at the end of the trajectory appear to be fusing options. Radar Updated Path Length fuzing is used on the W88, and probably the W76-1 to increase accuracy. A radar proximity fuze was also first introduced on the W88 and is likely to be a feature on the W76-1.

Contact Fuse on W76-1

The W76-0 has a contact fuse, MC2984.[29] This is part of the AF&F. With a contact fuse the warhead can detonate when it hits the surface. This results in a groundburst explosion. A groundburst can destroy hardened targets, such as bunkers and missile silos. It creates very large amounts of fallout. Experiments were carried out to determine how MC2984 would work if another warhead exploded close to it.[30] The UK Trident RB is likely to incorporate the MC2984.

The contact fuse on the new W76-1 is the MC4712. In FY2001 a computer simulation was designed to calculate how this fuse would function. The tests considered how the fuse would work if the warhead landed on a slope or an uneven surface.[31] The warhead hits the ground at very high velocity and could be destroyed before it detonates. The simulations produced a timing requirement within which the firing system would have to operate.



Radar

The radar system can detonate the warhead at high altitude or, as a proximity radar, closer to the target. It plays a key role in determining the Height of Burst of the nuclear explosion. The DOE have developed a computer model, E823F, to assess whether the radar on the W76 it is likely to detonate the warhead at the programmed height. This model is used to help determine the reliability of the warhead.

The MC2823 radar is a component of the AF&F system on the W76-0 warhead. It includes a gold microcircuit. There were concerns about suspected material problems with this radar system. The notes relating to this say: "customer preferred fuzing options, solid state electronics, corrosion concerns, complex technology".[32] Computer modelling of the W76 radar fuse was scheduled to have been carried out by FY2000 in order to revalidate this component.

The new AF&F for the W76-1 will include a radar system. A model of this radar fuse was to be produced by the 4th quarter of FY2001.[33] The radar on both the old and new systems is probably housed at the front of the AF&F on top of the battery.

Timer

The timer is used as a fuzing mechanism. The AF&F timer does not start when the missile is launched but later in the trajectory, possibly when the RB leaves the Post Boost Vehicle. The DOE uses reliability model BHOHL to assess effect of the timer on the programmed Height of Burst.[34]

Safety system

US nuclear weapons should include two strong links and one weak link. The theory is that the warhead can only be detonated when both strong links have been activitated. On the other hand the weak link should prevent the warhead from detonating in a fire. The stronglinks and weaklink are contained in the AF&F.

The two strong links in W76 are an intent stronglink and a trajectory stronglink. The intent stronglink is a mechanical device which keeps the circuit open until a unique electrical signal is received. This feature is referred to as Enhanced Nuclear Detonation Safety (ENDS).

The trajectory stronglink includes both an accelerometer and a decelerometer. The accelerometer detects the launch of the missile and initiates the pre-arming sequence. The decelerometer senses a prescribed number of "Gs" during re-entry. There were suspected problems with hermetic seals and fluid aging on the accelerometer in the AF&F in the W76-0. There was also concern about springs and lubricant in the decelerometer. These components are "safety critical".[35]

One of the requirements of the W76-1 refurbishment was that safety features were to be modernised. New intent stronglinks and trajectory stronglinks have been developed using minature mechanical devises and special lubricant material. A new weaklink capacitor has also been developed.

Firing System

The firing system supplies high voltage power to initiate the detonators on the primary of the warhead. The firing system within the AF&F on the new W76-1 is designated MC4702.

<u>Trigger set</u>

The trigger set on the W76-0 is the MC2983. Notes outlining potential problems with the MC2983 refer to "krypton, sprytron, glass insulators".[36] A sprytron is a vacuum tube that can very rapidly switch on a circuit.[37] It turns on the power supply to the firing set. The krypton is similar but is filled with gas. The DOE has a computer model of the W76-0 Sprytron.[38] This is used to assess the likelihood of a "Flare Dud". This is when the warhead detonates but does not have the predicted effect.

A new Micro Firing System was considered as an option for the W76-1. Sandia Laboratory has developed new spytrons. One model can be initiated with 100 rather than 1000 volts. It may be used for the W76-1.[39]

Firing set[40]

The W76-0 warhead uses the MC3028 Slim-loop Ferroelectric (SFE) firing set. Within the MC3028 a small quantity of high explosives is detonated to produce a pulse of high current electricity. This electricity sets off the main detonators

MC3028 Firing Set

There are two sub-assemblies in the MC3028. The explosive part is the MC2368 Driver. This contains PETN, an explosive with a relatively low melting point and low thermal stability. The second component is the MC3027 Transducer. This produces an electrical output of 1000 Amps. The MC3028 sends two electrical pulses, the first initiates the detonators in the primary and the second to operates the neutron generator. A graph suggests that power is supplied to a red circuit and then 0.5 microseconds later to a blue circuit.[41]

A list of suspected material problems within warheads has the following notes for the MC3028: “energetic material, dielectric, organics”.[42] The electromagnetic fields and other features of the firing set, including ageing, were modelled in FY2001.[43] A report on the revalidation and life assessment of the MC3028 was written in August 2002.[44]

The MC3028 is not only used in the W76 but also in the W78 Minuteman warhead. It is similar to the firing set in the older W68 Poseidon warhead. The MC3028 is probably also a component of the UK Trident RB. A British substitute is possible, but less likely.

The fabrication and testing of a functional prototype fireset for the W76-1 was scheduled for FY2003.[45] Computer simulations revealed deficiencies in the design and it was subsequently modified.[46] If W76-1 adopts an optical firing system then a different type of fireset would be required from that on W76-0.

Battery

The battery is located near the front of both the old and new AF&F systems. It supplies the substantial power required to detonate the main firing circuit. It also powers the neutron generator and AF&F components. The W76-0 includes the MC2936 Thermal Cadmium battery. The MC2936 was included in a list of components with suspected problems. The notes suggested that there was concern about the energetic and reactive materials within the battery and the potential for these to leak.[47]

Neutron Generator

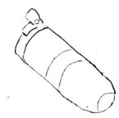
The neutron generator supplies neutrons to support the fission process when the warhead primary is detonated. A Sandia Laboratory report explains - "The proper function of a nuclear warhead depends on the presence of neutrons during primary implosion when the plutonium is supercritical. Neutron generators are located close to the warhead primary to produce a sufficient quantity of neutrons at that critical time".[48] The Neutron Generator functions as a miniature linear accelerator. A large charge is passed through a deuterium-tritium target.

The model of neutron generator that was used on the UK Trident RB was overhauled in the US. This is being been replaced by a newer US design that was delivered to the UK. This crucial component of British nuclear warheads is produced in America.

MC2989 (W76-0)

The MC2989 neutron generator was deployed on W76 warheads. In 1996 Sandia Laboratory began a four-year programme to recertified the units in service with the US Navy.[49] Each one was taken apart and inspected. The timer part was replaced. In one year 900 of these neutron generators were recertified.[50] In 1999 Sandia Laboratory was hired "to do the recertification work on the neutron generator assembly in a similar British weapon".[51]

It is likely that at this time the MC2989 neutron generator was installed in the UK Trident RB. Recertification would involve the same dismantlement, inspection, timer replacement and reassembly as carried out in the US program. This work would have been carried out in the US.



MC2989 Neutron Generator

MC4380 (W76-0 Alt 317)

In 1996 the MC2989 was considered to be approaching the end of its life.[52] The recertification process described above was only a temporary measure. A new neutron generator, the MC4380, was designed. Introducing this was part of the Alt 317 upgrade to the W76-0 warhead. Charts illustrating key milestones in the development of computer simulations to support the nuclear programme show that the MC4380 was a vital project between 1997 and 2002. One requirement was the ability to predict that the unit would operate in a hostile environment where there was radiation from another nuclear explosion.[53]

In earlier years replacement of a component of this significance would have involved a nuclear test. Paul Robinson of Sandia said of the MC4380 – "this will be the first time that a major component of US nuclear weapons will be introduced into the active stockpile without being qualified through nuclear tests."[54]

In February 2003 a Sandia Laboratory news item on the MC4380 referred to "delivery of the first units to the Navy and the UK last summer."[55] This means that these US-built neutron generators were supplied to Britain for use on the UK Trident RB. The neutron generator is a key major part of a nuclear warhead without which the primary will not produce the intended nuclear yield. This vital component of the British Trident warhead is not produced in this country but purchased from the US.

There are several main components of the new neutron generator. The MC4277 neutron tube is where the ionisation process takes place. The deuterium-tritium target is manufactured at Los Alamos. MC4378 is the timer unit.

The electrical pulse is supplied by another sub-component, the MC4368 power supply. This is an explosive-driven ferroelectric unit.[56] A paper written in 2001 refers to a revised design, MC4368A, and this is probably now deployed.[57]

Neutron generator power supplies use a special material, PZT 95/5. Although the evidence suggests that the US now builds the neutron generators for British warheads, Aldermaston has investigated how to make PZT 95/5. Sandia Laboratory obtained details of the Aldermaston process but found there were problems with it. So Sandia devised their own process and this is being used to support the manufacture of new neutron generators.[58]

Standoff

There are several references to the need to develop a computer model of "neutron generator standoff" for Trident in FY1997. Standoff is the time interval between when the High Explosive in the primary detonates and when the neutron generator should function. Information on the MC3028 firing set suggests this time interval may be 0.5 microseconds.

Two of the sources refer to the Warhead Protection Program Pit Reuse Project, a plan to design a replacement warhead.[59] One refers to the W76 warhead. Another has a milestone for "neutron generator standoff for contact fuze mode". The functioning of the neutron generator is likely to be a crucial issue in calculating whether the warhead will operate as planned if the process is triggered by a contact fuze on impact with the ground, as with the W76-1.

Gas Transfer System

The gas transfer system of a nuclear warhead feeds tritium into the primary shortly before it is detonated. This boosts the yield from the fission reaction by facilitating the fusion of hydrogen isotopes.[60] In 1994 a review of the Stockpile Stewardship Program noted that the way in which boosting worked was one area where a greater level of understanding was most required.[61]

The early model of Gas Transfer System on the W76-0 was called Heather. This was replaced by a new design, Acorn, as part of Alt 317 to the W76-0. Acorn had been due to enter service in 1998 but "verifying it proved a challenge".[62] Los Alamos Laboratory had problems arranging appropriate shock and vibration tests. Crucial testing was only completed in 2000.[63] The new system is now in service. The system includes valves to control when the pressurised tritium is inserted into the warhead. Sandia Laboratory designed explosively-actuated valves which are used on all nuclear weapons.[64]

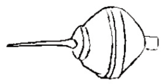
The tritium is contained in the SP981 gas reservoir.[65] These are filled with tritium at the Savannah River Site, as are the reservoirs for all other US nuclear weapons. At this plant a new loading line was set up for the W76 Acorn.[66]

The US has declassified the fact that tritium reservoirs are "shipped between the Savannah River Plant and the AEC weapon facilities, the military and the United Kingdom".[67] In 1997 the Government was asked about Special Nuclear Material (SNM) flights between Brize Norton and the US. Lord Gilbert replied that the term SNM covered tritium.[68] British tritium is transported to America as Uranium Tritide.[69] It is loaded into gas reservoirs at the Savannah River Site.

Tritium is radioactive and can penetrate stainless steel. It decays to produce helium, increasing the pressure within the reservoir. Because of the peculiar problems of storing tritium the reservoirs and Gas Transfer Systems are specialised components. It is likely that both the reservoirs and the Gas Transfer Systems for British warheads are built in the US.[70] The neutron generators on the UK Trident RB were replaced in line with the American Alt 317 upgrade. It is likely that the other part of this Alteration, the Acorn Gas Transfer System, has also been introduced in Britain.

In the US a new Gas Transfer System is being developed for the W76-1. The Acorn system was established as the baseline technology for the new design.[71]

The Gas Transfer System plays a vital role in determining the yield of the warhead. It is a key component of the UK Trident RB. Britain has a stock of tritium, but this can only be transformed into a warhead component by using US facilities and probably a US-manufactured Gas Transfer System.



Gas Transfer System

Radiation case

The radiation case is the metal cladding that encloses both the primary and the secondary of the warhead. The function of the case is to channel radiation energy from the primary to the secondary before the assembly disintegrates. In 1994 the Stockpile and Stewardship Program report said that the behaviour of the case was poorly described in existing models.[72]

Richard Morse, a former theoretical physicist at Los Alamos, expressed concern about the radiation case on the W76 warhead in 2004.[73] During the 1970s Los Alamos had competed with Lawrence Livermore to design a new lightweight warhead for the Navy. Los Alamos won the contract by proposing a warhead with a thin and light radiation case. This W76 design was tested in a series of underground nuclear explosions at the Nevada test site. In 1969 one test produced a low yield. Richard Morse argued that this was because the case was too thin. In 1992 a nuclear test to verify this issue was planned and then cancelled because of testing moratorium.

Richard Morse said that the W76 should be redesigned with a heavier case. Using the Mk4 RV this would reduce the yield by 40%. Alternatively a heavier version of W76 could be incorporated into the Mk5 RV. Morse met with representatives of the US laboratories on several occasions, most recently in March 2004, but his approach was not accepted.

This explanation of the warhead's history has been disputed. Bob Peurifoy, a retired expert from Sandia Laboratory, admitted: "There was a device-yield test during development that, because of some engineering oversight, did not deliver the expected yield".[74] He added that the problem had been corrected.

Primary

The primary is an ellipsoidal assembly which produces a fission yield through implosion. A typical primary contains a series of hollow spheres or shells, inside each other. The outer shell is high explosive. Below this there is a tamper. The tamper serves two functions. It contains the critical mass in the centre before it expands. It also reflects back neutrons which have escaped from the critical mass.[75] Nuclear warheads may use one metal for both functions, or two metals in separate shells. Beryllium provides an efficient reflector and is used in the UK Trident RB.[76] In general nuclear warheads may also use Uranium or Tungsten to contain the explosion. The pit at the centre of the warhead is made of approximately 4 kgs of plutonium. Shortly before detonation tritium is injected down the pit tube into the hollow centre of the pit.

High Explosive

The high explosive in the US W76 warhead is PBX9501. During the W76-1 refurbishment programme this explosive will be replaced. The W76-1 project is based on the assumption that the replacement PBX9501 can continue to be used for 30 years. The main focus of the High Explosive element of the US nuclear weapons programme is the production of this replacement explosive for W76-1.[77]

This is one area where the UK Trident RB differs from the W76. A British explosive, EDC37, is used instead of PBX9501. Although the two explosives have a similar density their composition is different.[78] The base explosive in each is HMX but the proportions are different. PBX9501 consists of 95 % HMX, while EDC37 has 91% HMX and uses an energetic binder. The HMX in EDC37 is also in finer particles. The binder in EDC37 is softer than the formula used in PBX9501. Because the binder is different the mechanical response to initiation is not the same.[79] Experiments have shown that EDC37 is less sensitive, ie harder to detonate, than PBX9501.[80] However EDC37 is not an Insensitive High Explosive.[81]

The use of a different explosive has two implications. Firstly, the way in which the primary operates will not be identical. Secondly, separate safety assessments will be required to demonstrate the response of EDC37 to shock and heat.

Both the performance and the safety of the warhead are affected by the aging of the explosive. PBX9501 has been in service on US Trident warheads for 26 years, as of 2005, more than twice as long as EDC 37. An Aldermaston report published in 2002 highlights the uncertainty surrounding predicting the effect of aging on EDC37. An analysis of trials has concluded: “it appears that aged material cannot be totally mimicked by starting with lower molecular mass material.”82 With regard to the changing mechanical properties of the explosive it said “it is deduced that while molecular changes within the nitrocellulose polymer have a profound effect upon the resultant PBX mechanical properties other, as yet, unidentified factors also play a role.”83 Aldermaston appear to be replacing the high explosive after 12 years.84 A substantial further extension of the explosive life would be hard to achieve.

The research programme for EDC37 gives an insight into the relationship between the British and American nuclear weapons' establishments. One Aldermaston report describes use of the Witham-Bdzil-Lambourn (WBL) model to predict the detonation wave for EDC37.85 In a comment on this report an American scientist complains that it fails to acknowledge that the British WBL model was based on briefings he had given while visiting Aldermaston. One of the British scientists disputed this and said that WBL was "an example of parallel and convergent development, with interaction between groups at AWE and LANL".86

While some studies on EDC37 have been done at Aldermaston, others have been carried out jointly with US counterparts, and some have been done only in the US. As with all other aspects of nuclear weapons, the development and verification of computer models is crucial. To analyse explosive safety Lawrence Livermore Laboratory is developing the Stevens Impact Test. This will produce data that can form a basis for computer simulations. At first six US explosives were investigated. Later EDC37 was added to the list of explosives used in trials.87

Aldermaston has published a report on a simple model of hot spot initiation for EDC37.88 Los Alamos Laboratory carried out related studies into the initiation of this explosive.89 A joint report, by both laboratories, into the double shock initiation of EDC37 has also been published.90

Detonators

The W76-0 uses Exploding Bridge Wire (EBW) detonators.91 A powerful surge of current heats a thin wire, probably gold, to the point of vaporisation.92 This sets off a detonator charge, probably PETN, which in turn initiates the main explosive.93 EBW detonators are placed around the warhead High Explosive. The detonators should go off simultaneously and should initiate the main charge so that it evenly compresses the plutonium pit from all sides.

Initiating the HE in a nuclear warhead by light was investigated in the 1980s. This project was mothballed in 1992 but was revived as the Direct Optical Initiation System for the W76-1. Qualification testing of the new method was scheduled to meet the W76-1 timeline.94 The development of a laser fired fibre optic controlled detonator for the W78 and for future SLBM warheads should be completed in FY2005.95 Currently the W76 and W78 use the same fireset, so it is not surprising that the new system is being developed as a replacement for both warheads.

Detonators for British nuclear weapons are designed at Aldermaston and produced at Burghfield. Two British detonators were tested at Los Alamos – the Mk13C and the Mk22A.96 It is likely that one of these is used on the UK Trident RB. These are probably EBW detonators. The fact that the EDC37 on the UK Trident RB is less sensitive than the PBX9501 in US warheads will affect detonation calculations. There will be a specific effort to model and verify this detonation system.

Hydrodynamic testing

Hydrodynamic testing is subjecting small amounts of metal to investigate how it behaves when compacted in situations similar to those found when a warhead is detonated. Most of these experiments are carried out using tantalum, lead or depleted uranium, but some use plutonium.97 Hydrodynamic testing has been a problem area in the US W76-1 programme. A test from FY2002 had to be repeated and four tests scheduled for FY2003 were postponed. An appraisal of the work of Los Alamos in FY2003 said "hydrotests remain a concern".98 The UK has participated in a recent joint US/UK test where plutonium was detonated at the Nevada test site without producing a nuclear yield. This was part of the hydrodynamic testing programme.

Inspections of warhead primaries

Since Trident has become fully operational, with three armed submarines, the production of warhead primaries at Aldermaston has continued, albeit at a low rate. Each year Aldermaston inspects several warheads that have been withdrawn from service for routine surveillance. These inspections damage the primary to the extent that it cannot be reassembled. The ongoing primary production is to replace those damaged during this surveillance process. The scale of this surveillance effort suggests that Aldermaston scientists may doubts about material changes within the primary over time. These changes could affect safety or the designed yield.

Secondary

The secondary is the fusion component in a nuclear weapon. It increases the yield of the warhead by a factor of around ten. The main component of the secondary of the W76 and the UK Trident RB is made of Highly Enriched Uranium (HEU). Development of computer models for the secondary of the W76 warhead has been a problem area for the US programme. The conclusion of the Dual Revalidation, in 1999, said progress had been made in baselining and benchmarking the secondary. Later reports indicate that this work is progressing slowly.

The interaction of materials in the secondary may cause problems as the warhead ages. A 1997 US report identified the moisture content of organic materials in the Canned Sub Assembly, or secondary, as one focus for research. Hydrogen from these materials can lead to the formation of uranium hydride.99

In 2000 there was a substantial surveillance effort looking at the secondaries in British warheads. This was required to support plans to extend the life of the warhead. As with the US programme, there may be a critical degree of uncertainty about how the secondary in the UK Trident RB would perform over the longer term.

Reliable Replacement Warhead

In 2005 Congress diverted funding from the design of new warheads into a new concept study, the Reliable Replacement Warhead (RRW).100 The House Armed Services Committee urged that the initial focus should be on replacement SLBM warheads and the Navy is chairing the RRW Project Officers Group. So a replacement for W76 is likely to be high on the agenda of this study. RRW is expected to focus on components in the Nuclear Explosives Package, as Life Extension Programs can already substantially modify other parts. The initial focus is likely to be on replacement pits.101 This implies that RRW may first look at a replacement pit for W76. If the new project is continued it is planned to have a redesigned warhead by between 2012 and 2015. The first batch of W76-1 warheads are to be completed by 2012. RRW may provide an alternative to continuing with the W76-1 upgrade.

RRW is expected to consider how to trade Cold War priorities, such as high yield/weight ratios, for reliability. This could result in a heavier Trident warhead, possibly using Insensitive High Explosive. Some nuclear experts have questioned the feasibility of the RRW programme.

Notes

1. Known alphanumeric codes are listed at www.skomer.u-net.com/projects/alpha.htm

2. In FY2007 the DOE will restart pit production to build more W88 warheads.

3. Public Records Office, Operational Selection Policy, OSP 11, Nuclear Weapons Policy 1967 – 1998.

4. Stockpile Stewardship Program 30 day review DOE 23 Nov 99

5.

6. LANL W76-1 overview

7. Duke Williams, Space Systems chief engineer for Navy Re-entry Systems, Space Daily, 11 July 2000

8. Stockpile Stewardship Program 30 day review DOE 23 Nov 99

9. The concept of a pre-planned life for nuclear weapons has been questioned. J Medalia, Nuclear Weapons: The Reliable Replacement Warhead Program, Congressional Research Service, 20 July 2005

10. LANL W76-1 overview

11. Minutes of evidence 16 March 1994. Progress of Trident, House of Commons Defence Committee, HC 297, 1994.

12. The joint DoD/DOE study into the W76-1 was initiated by the Strategic Systems Program and the Standing and Safety Committee of the Nuclear Weapons Council. LANL W76-1 overview, www.lanl.gov/orgs/d/d5/projects/W76/W76-1-LEP-Overview.htm

13. LANL W76-1 overview, ; In general warhead LEP programs are expected to extend life by 20 years, with a target of 30 years.

14. Ibid: the Submarine Warhead Protection Program initiated in 1995 showed the desire to increase targeting flexibility.

15. There are three levels of testing and certification used in STS and other nuclear weapons projects: <u>Normal</u> This simulates the minimum conditions the warhead would encounter; <u>Abnormal</u> This includes responses to fire and collisions and relates to warhead safety; <u>Hostile</u> This simulates the warhead's ability to operate in a radiological environment. This is used to predict vulnerability to nuclear Anti Ballistic Missiles and also to fratricide from other US warheads (Fratricide. Is mentioned in ASCII DP50 budget brief for FY1999.)

16. DOE FY2005 Nuclear Weapons Budget, Directed Stockpile Work

17. DOE FY2005 Nuclear Weapons Budget, Advanced Simulation and Computing Campaign

18. Bulletin of Atomic Scientists, Nuclear Notebook January 2005

19. Hansard, House of Commons, 6 February 2002; In US practice "safety and reliability" can include working on a new warhead.

20. MoD response to Defence Committee Inquiry into the UK Strategic Deterrent, July 2006

21. The Nuclear Explosive Package is also referred to as the physics package in some British reports. The drawings are based on photographs in Materials Aging in the Enduring Nuclear Weapons Stockpile, D Salzbrenner, M Perra, W Cieslak, SNL

22. Space Daily 11 July 2000

23. DoD Contract N00178-03-R-1044.

24.David Kramer, Inside Energy/with Federal lands, May 1994, quoted in The Next Chevaline Scandal? , CND, August 1999.

25.

26. Drawing from Analysis for Design of the MC4700 Replacement AF&F for the W76-1/Mk4A, Sandia Laboratories.

27. Aldermaston job vacancy for Warhead Electrical Engineer. This refers to the Warhead Electrical System which is an alternative name for the AF&F.

28. "Joint DOE/DoD Stockpile to Target Sequence", Gilbert Weigand, Petaflops II conference, 18 February 1999

29. The impact fuze on the W76-0 is MC2984 and on the W76-1 is MC4712; Sandia Lab News 18 March 2005.

30. Sandia Lab News 18 March 2005

31. Paul Dimmie, Analysis for Design of the MC4700 Replacement AF&F for the W76-1/Mk4A, and Collisions of the W76-1/Mk4A with Obstacles and Impacts with Irregular Targets, Computational Physics and Simulation Frameworks, Sandia FY2001 Department Review, 30 May 2001.

32. Salzbrenner op cit

33. ASCI Q3 FY2001 report

34. Salzbrenner op cit

35. MC2854 Environmental Sensing Device (ESD) (Accelerometer) & MC2897 ESD (Decelerometer), Salzbrenner op cit

36. Salzbrenner op cit

37. Carey Sublette, High Energy Weapons Archive. http://nuketesting.enviroweb.org/hew/

38. The Sprytron model is E028Q1

39. Sandia Labs Accomplishments 12 February 1999 and 11 February 2000 and Carbon Thin Films for Enhanced Sprytron Tube Performance, Science Base for Enhanced Materials Performance and Reliability, Sandia website.

40. Drawing from Modelling the MC3028 Firing Set and Simulating its Performance, Computational Physics and Simulation Frameworks, Sandia FY2001 Department Review, 30 May 2001.

41. Ibid. A microsecond is one millionth of a second.

42. Salzbrenner op cit

43. Modelling the MC3028 Firing Set.

44. Sandia National Laboratory publications list

45. DOE Nuclear Weapons Campaign Activities budget FY2003.

46. Sandia Lab News March 2004

47. Salzbrenner op cit; The W76 battery has also been described as a Ca/CrO4 battery.

48. Sandia Accomplishments – Nuclear Weapons

49. Sandia Lab News 15 January 1999; A statement by Paul Robinson of SNL in 1997 indicated that processing had begun on units returned from the field.

50. SNL Accomplishments – Nuclear Weapons. The year concerned was probably 1998.

51. Sandia Lab News 15 January 1999.

52. www.doe.gov/rnd/data/35858.html

53. A 3D model of x-ray radiation transport throughout the RV was developed between FY1997 and FY1999 to predict the radiation hardness of the MC4380 neutron generator. Sandia Lab News 28 January 2000

54. Statement by Paul Robinson on Stockpile Management, 26 February 1999.

55. Sandia Lab News February 2003

56. Neutron Generator Power Supply Modeling in EMMA, SNL, November 1996.

57. Characteristics of the precision laser beam welding process for the MC4368A neutron generator, SNL, Sept 2001.

58. Solution Synthesis and Processing of PZT Materials for Neutron Generator Applications, SNL Laboratory Directed Research and Development FY 1996. Sandia Lab News 11 February 2000.

59. Paul Robinson SNL 1997

60. Sandia Factsheet on Gas Transfer System

61. Stockpile Stewardship Program 1994

62. LANL reflections December 2002.

63. Sandia Annual Report 2000

64. Gas Transfer Systems factsheet, SNL

65. MB White, Final Report: Stem Drop testing of aged stems on the SP981 reservoirs, Westinghouse Savannah River Company, 26 April 1999

66. Savannah River Site Fact Sheet Loading Line Modification Project

67. US Department of Energy, Restricted Data declassification decisions 1946 to the present (RDD-7), 1 January 2001. www.fas.org

68. Question from Lord Jenkins and reply from Lord Gilbert, Hansard 25 November 1997

69. US practice is that Tritium is absorbed into Uranium at room temperature, as Uranium Tritide. This is later heated. Tritium and its decay product, Helium 3, are extracted at different temperatures.

70. The reservoirs will be manufactured at the Kansas City Plant.

71. LANL Institutional plan FY2003 – FY2005.

72. Stockpile Stewardship Program report 1994.

73. Articles by John Fleck in the Albuquerque Journal, 8 July 2004 and 29 October and letters to the same paper by John L Richter and Richard Morse in November 2004.

74. Article by John Fleck in the Albuquerque Journal, 8 July 2004

75. Carey Sublette, High Energy Weapons Archive, nuclearweaponsarchive.org

76. Beryllium components were manufactured in Cardiff. After the closure of AWE Cardiff the equipment was moved to Aldermaston.

77. DOE Nuclear Weapons Budget FY2005, Weapon Activities.

78. EDC37 consists of (by weight) 91% HMX, 1% nitrocellulose and 8% K10. K10 is a liquid eutetic mixture of di-nitro-ethyl-benzene and tri-nitro-ethyl-benzene, RL Gustavsen et al, Abstract of Initiation of EDC37 Measured with embedded Magnetic Particle Velocity Gauges, MoD Interim Defence Standard K10 Liquid, 17 August 1994; PBX9501 is 95% HMX, 2.5% estane and 2.5% BDNPA-F, Carey Sublette, High Energy Weapons Archive,

79. RN Mulford & DC Swift, Abstract of Modelling of Initiation Behaviour as a Function of Some Mechanical Properties for HMX-based Explosives, LANL, June 2001.

80. SK Chidester et al, Single and Multiple Impact Ignition of New and Aged High Explosives in the Steven Impact Test, LLNL, June 1999.

81. Britain has also developed EDC35, a TATB-based Insensitive High Explosive, but this is not used on the UK Trident RB; AM Collyer et al, WBL Detonation Wave Propagation for EDC35 and EDC37, AWE 1998.

82. PJ Rae et al, The use of digital image cross-correlation (DICC) to study the mechanical properties of a polymer bonded explosive (PBX), MoD 2002.

83. ibid

84. The basic predicted life of the explosive was 10 years. Samples were monitored to see if this could be extended to 12 or 14 years. One of the samples in an EDC37 aging study was being stored for 4380 days, ie 12 years – ibid. The frequency of nuclear weapons convoys suggests that the refurbishment is underway in 2005, 12 years after the first warheads were delivered.

85. AM Collyer et al, WBL Detonation Wave Propagation for EDC35 and EDC37. AWE, 1998

86. ibid, Comment from DS Stewart and reply by DC Swift in discussion

87. Chichester op cit

88. NJ Whitworth, Development of a Simple Model of Hot Spot Initiation in Heterogeneous Solid Explosives, AWE 2001.

89. RN Mulford &DC Swift, Modelling of Initiation Behaviour as a Function of Some Mechanical Properties for HMX-based Explosives, LANL, 2001.

90. RL Gustavsen, SA Sheffield & RR Alcon (LANL) and RE Winter, P Taylor, DA Salisbury (AWE), Double Shock Initiation of the Explosive EDC37, 2001.

91. US warheads that incorporate Insensitive High Explosive are likely to use Exploding Foil Initiator (EFI) detonators, also known as slappers, rather than EBW.

92. Sublette op cit; CM Furnberg et al, Computer Modelling of Electrical Performance of Detonators, American Institute of Aeronautics and Astronautics; Computer Modelling of Electrical Performance of Detonators, SNL.

93. There is a US research project to investigate the use of Insensitive High Explosive in warhead detonators.

94. Sandia Labs Accomplishments 12 February 1999 and Sandia Labs Accomplishments 2004.

95. FY2005 DOE Nuclear Weapons Budget

96. High Explosive Spot Test Analyses of Samples from Operable Unit (OU) 1111, LANL, January 1995.

97. K O'Nions, R Pitman and C Marsh, Science of nuclear warheads, Nature, 21 February 2002

98. FY2003 Appraisal of University of California / LANL.

99. Enhanced Surveillance Program FY1997 gpo.osti.gov

100. J Medalia, Nuclear Weapons: The Reliable Replacement Warhead Program, Congressional Research Service, 20 July 2005

101. Department of Energy Budget request for FY2006

Annex J
Nuclear weapons development process

Nuclear Weapons interchange between the US and Britain

The ongoing exchange of nuclear weapons information between Britain and America takes place under the Mutual Defence Agreement of 1958. The Joint Atomic Information Exchange Group controls the release of US nuclear weapons design information. The main means of interchange are Joint Working Groups (JOWOGs). New working groups can be created and existing ones amended or deleted at the annual high-level Stocktake meeting.

Over the years there have been a total of 25 JOWOGs. 16 of these were active in 2002. The groups held a total of 181 meetings in 2001.[1] 61 of these took place in the UK and the remainder in the US. Most meeting in the UK are at Aldermaston while US meetings are normally at Los Alamos National Laboratory, Lawrence Livermore National Laboratory and Sandia National Laboratory.

JOWOGs have sub-groups (SUBWOGs) concentrating on particular areas. There are also Focused Exchange meetings of JOWOGs on individual topics. Some sub-groups meet quarterly, but most probably meet once or twice a year. In 2001 there were, on average, 11 meetings per JOWOG.

70-100 people have attended some meetings of JOWOG 37, Laboratory Plasma Physics. However most JOWOG meetings are smaller. JOWOG meetings are normally over 2 days and the participants discuss several scientific papers.

Most of the papers are of US origin and a small minority are submitted from Aldermaston. It is possible that several hundred papers are discussed each year at these meetings.[2] The papers are on a range of subjects related to nuclear weapons science, practical procedures and safety issues. Some JOWOG papers are available on the internet.

There are also three working groups that deal directly with Trident.[3] These are the Joint Steering Tasks Group, the Trident Joint Re-Entry Systems Working Group and the Joint Systems Performance and Assessment Group. In addition there are Exchange of Information and Visit Reports (EIVRs).

There is clearly a substantial exchange of information between Britain and the US on nuclear weapons issues. The flow of knowledge is overwhelmingly, but not exclusively, from America to the UK. Nevertheless this volume of interaction does not mean that the two countries are entirely open with each other. There is information on Trident warheads which the US does not share with Aldermaston. Conversely there are details of the British Trident warhead programme that are not shared with their American counterparts.

Computer simulations - United States

The US has not ratified the Comprehensive Test Ban Treaty, but has observed a moratorium on testing since 1992. In recent years the US nuclear weapons establishment has reduced the time lag between a decision to resume testing and the first test occurring.[4]

The Stockpile Stewardship Program was set up to develop alternative ways of verifying nuclear weapons. The main mechanism for doing this is the Advanced Simulation and Computing (ASC) initiative. ASC is a massive project. The Administration plans to spend over $ 4 billion on ASC between FY2005 and FY2009.[5] Expenditure in earlier years was around $700 million per year. In FY2005 the cost of the ASC program is equivalent to $5.7 million per Teraflop of computing power.[6]

The current plan for increasing ASC computing power is shown in the table.[7]

Year FY	**Platform Power** Teraflops	**Total Power** Teraflops	**Storage** Petabytes	**ASC Simulations**
1996	1	?	?	
1997	1	?	?	W76-0 Neutron Generator Standoff
1998	3	?	?	
1999	3	?	?	W76-0 Neutron Generator Radiation Hardening
2000	10	?	0.5	3D primary prototype; W76-0 radar fuse
2001	10	?	1	3D secondary prototype; STS normal prototype
2002	20	?	5	3D primary & secondary prototype; STS abnormal prototype
2003	20	41	10	3D high-fidelity primary & secondary separate initial capability
2004	20	75	25	3D high-fidelity full-system initial capability
2005	100	172	50+	Full system STS initial capability
2006	100	160	?	Initial validated simulation code for W76-1 & W80-3
2007	150	310	?	W80-3 code baseline
2008	150	420	?	Full Coupled STS abnormal; Codes for CD-4 approval on NIF
2009	350	930	?	Baseline all stockpile systems; QMU for W76-1
2010	350	930	?	
2011	?	?	?	
2012	?	?	?	
2013	?	?	?	Codes to support indirect-drive ignition experiments on NIF

Platform power is for one computer system, whereas total power is the combined capability of all the ASC computers. Both are measured in

Teraflops. One Teraflop is a thousand billion floating point operations per second.

Some of the initial simulations took a long time to run. For example, in 2000 an early trial secondary prototype simulation ran for 1016 hours.[8] US nuclear weapons designers want to move to Petaflop computing (a Petaflop is 1,000 Teraflops). They argue that Petaflop computing would "begin to make 3D simulations analytical tools rather than just enabling a tour-de-force calculation."[9] The 2005 report into the ASC project said that the highest risk factor was that the computing power available would not be adequate for the task. This suggests that they want more power than is in the current schedule.

In 2001 the four most powerful computers in the world were all in the US nuclear weapons program. In 2002 these were overtaken by the Japanese Earth Simulator, which has a power of 35 Teraflops. The nuclear planners are overtaking this.

The storage capacity is also on a gigantic scale, measured in Petabytes. The requirements for the nuclear weapons programme are compatible with those of Google, the main internet search engine.[10]

In May 2004 Oak Ridge National Laboratory (ORNL) won a competition between the US nuclear sites to build a new computing centre. The current computer at ORNL was to be upgraded to 20 Teraflops in 2004, then an additional computer with similar power, Red Storm, added in 2005. A new building will be constructed with 40,000 square feet of computer space and 400 staff.

There are two main developments under ASC, nuclear applications and non-nuclear applications. The nuclear application program has developed prototypes models to simulate the detonation of a primary and then of a thermonuclear secondary. These were followed by a prototype model of a coupled simulation of both primary and secondary. The initial capability of the coupled simulation was to be established by the end of FY2004.[11] US nuclear weapons development is done first for normal environment, then for abnormal environment, such as during an accident, then for the hostile environment of nuclear war. The initial capability of this simulation was for normal conditions. The target for completing a full coupled simulation for abnormal environment is FY 2008. The prototype model uses the W80 cruise missile warhead.[12] A model of the W76 will be developed at an early stage.

The non-nuclear applications program has developed a Stockpile to Target simulation to model the conditions which a warhead would encounter. Again the initial prototype model was for a normal environment. A prototype for abnormal environment was to be developed in FY2004, followed by an abnormal environment model in FY 2005.[13] The warhead used in the initial model was the W76. The simulation included the flight conditions the re-entry vehicle would encounter, the operation of the radar and contact fuses and the Arming, Fusing and Firing system in the warhead. Full accomplishment of the Stockpile to Target simulation for normal environment is to be accomplished in FY2007.

The accuracy of the models is checked by the Validation and Verification program. This has been defined in these terms: "Verification determines that a software implementation correctly represents a model of a physical process. Validation determines whether a computer model correctly represents the real world".[14] The models are tested against two types of data: information from nuclear tests, and results from experiments. Reports from tests carried out at Nevada and elsewhere are being collated by the Nuclear Weapons Archiving Project. A priority in this work is to gather a large volume of data from W76 and W80 nuclear tests. Where there are anomalies in test results research is being carried out to try to understand these anomalies. The facilities used to gather new experimental data are outlined below.

Predicting accuracy also involves the calculation of Quantitative Margin and Uncertainties (QMU) logic. The first warhead for which this is being carried out is the W76. QMU logic for this warhead is to be completed by FY2009.

Computer simulations - Britain

The Strategic Defence Review and subsequent statements have said: "it is our policy to maintain a minimum capability to design and produce a successor to Trident should this prove necessary".[15] However, without resorting to a nuclear test, Aldermaston is not currently capable of designing a successor weapon within the bounds of safety and reliability. The summary of a presentation by Darel Landeg, computer director at AWE, revealed that their mission was to "develop the capability to produce a successor system without recourse to underground nuclear warhead tests."[16]

As with the US, the key is the construction of complex simulations. In 2002 AWE installed a new computer, Blue Oak, with a power of just under 3 Teraflops.[17] While this will be able to run models of components of nuclear weapons, and replicate features of a nuclear detonation, it will not be able to carry out a full 3D simulation of a nuclear detonation.

A two year programme to "introduce the next level of computing at

AWE" was due to start in 2004.[18] Darel Landeg said that they would require computers with a power of 25 Teraflops by 2005 and hundreds of Teraflops by 2010.[19] Other reports indicate that Aldermaston's computing strategy was to move to 100 Teraflops by 2012.[20]

These planned systems would approach the power, and cost, of the machines which the US is developing. This computer programme is likely to be very expensive. The US example suggests that the hardware is only around 20 % of the overall budget for these simulations.[21]

AWE collaborates with the US laboratories in the "Joint Test Programme" to improve warhead modelling.[22] As part of this programme AWE have developed a Finite Element model of the UK Trident Re-entry Body. There is also a joint LLNL, AWE and IBM project on improving synchronous operations on High Powered Computers

Britain has already obtained a component that was tested in the US system. The MC 4380A neutron generator was certified as a result of tests carried out by computer simulation within the US program. Since 2001 it has been manufactured in the US for use on both American and British Trident warheads.

It is likely that while the US allows Britain to use its computer facilities for limited tasks, and helps AWE to develop its own simulation system, they are not willing to construct a full-scale simulation of a British warhead within ASC. The history of Anglo-American nuclear collaboration suggests that the US has been most willing to open up its own files when Britain is carrying on its own research, and least willing to collaborate when very little research was being done in the UK. Today this is measured by the development of computer simulations. It is likely that access to US design information will be determined by the extent to which AWE develops an independent computer simulation system.

The substantial computing power that Aldermaston is seeking could be put to far better use. The 35 Teraflop Earth Model on the Japanese supercomputer has simulated the creation and progress of tsunamis. Meteorologists would like to have computers with powers of over 100 Teraflops. These could be used to predict the paths of hurricanes and save lives, rather than for designing weapons of mass destruction.

Experimental facilities – US

Trials are carried out in order to check and validate the computer models that are being created. The main facilities are used to subject small amounts of material to high temperature and pressure in order to examine how these materials perform when they are used in nuclear weapons.

These included studies of the primary of a weapon, this is the fission stage of a device. Primary studies consider the effect of imploding Plutonium. Experiments into the behaviour of the High Explosives used are also carried out. The other major nuclear component of a weapon is the secondary or thermonuclear element. Experiments on this include studies of the performance of deuterium and tritium when subjected to high temperature and pressure.

Some of the main facilities are:

National Ignition Facility (NIF)
The term "ignition" refers to "simulating fusion conditions in a nuclear explosion".[23] Developing computer codes for the secondary of nuclear warheads will be the main focus of research at NIF.[24] In the facility laser pulses will be fired at deuterium-tritium targets.[25] NIF will also be used for other nuclear weapon research.[26] It is due to be available in FY2005 and to be completed in FY2008. Britain will be able to use NIF.

Dual Axis Radiographic Hydrotest (DAHRT)
DAHRT produces 3D imagery of primary implosion. The second axis should become available in FY 2006. The initial priorities will be supporting the W76, B61 and W88 warheads.

Nevada Test Site
The main purpose of sub-critical experiments at the test site is to investigate the performance of warhead primaries.[27] A focus of these tests has been the primaries of W76 and W88 Trident warheads. Britain has carried out sub-critical experiments at Nevada.

Joint Actinide Shock Physics Experimental Research (JASPER) facility
JASPER plays a key role in experiments to understand the behaviour of plutonium. The FY2005 budget increased funding for JASPER because fewer sub-critical tests were to take place at Nevada and more experiments carried out at JASPER instead.

OMEGA pulsed laser facility at the University of Rochester
OMEGA is used to support secondary codes.[28] The FY 2005 budget allocates funds to expand this facility.[29]

Z-facility at SNL
The Z facility studies material response at high pressure, provides support for secondary codes and EOS. It also has carried out work on deuterium.

HE testing

A focus of HE testing for FY2005 is a replacement PBX901 for W76-1. This includes flight-testing this explosive in a Trident test flight.[30]

Experimental Facilities – Britain

In July 2005 the MoD announced that £350 million would be spent in each of three successive years on facilities at AWE. It is likely that this will include new computer equipment, a new laser facility and other developments.

ORION

In 2005 AWE applied for planning permission to build a new laser facility, ORION. This is designed to be 1000 times more powerful than the 20 year old HELEN laser, which it is intended to replace.[31] The specifications are for a facility with a power measured in Petawatts and Energy measured in Kilojoules.[32] Short bursts from the two lasers will create very high temperatures and pressures similar to those of a nuclear explosion. Information on NIF and OMEGA suggests that ORION would be used primarily, but not exclusively, for experiments related to the thermonuclear secondary of a warhead.

VULCAN

AWE uses the VULCAN laser facility operated by Rutherford Appleton Laboratories.[33]

Aldermaston scientists also have access to US test facilities.

Notes

1. Written answer from Dr Lewis Moonie, Hansard, 25 January 2002; There were similar numbers of meetings in 1999 and 2000.

2. Assuming an average of 4 papers per meeting, there would be 724 papers for 181 meetings.

3. Public Records Office, Operational Selection Policy OSP11, Nuclear Weapons Policy 1967-1998.

4. The time required to re-introduce testing is to be reduced to 18 months by FY2005. Nuclear Weapons Campaigns budget FY 2005, p84.

5. Advances Simulation and Computing budget FY2005 – FY2009 ($ millions) Nuclear Weapons Campaigns budget FY 2005.

6. Nuclear Weapons Campaigns budget FY 2005, p132.

7. Nuclear Weapons Campaigns budget FY2006, ASC, jp159

8. ASCI Update November 2000

9. ASC Strategy the next 10 years, August 2004

10. Google required between 2 and 4 Petabytes in 2003.

11. ASCI program 2001

12. The W80 Life Extension project has been described as a joint warhead development and computer simulation development. Sandia Labs Annual report

13. Nuclear Weapons Campaigns budget FY 2005.

14. ASCI plan 2001

15. Written Answer from Geoff Hoon 12 June 2003, Hansard

16. IDC High Performance Computing User Forum, London, 22 October 2003.

17. Jim Taylor, History of Scientific Computing at AWE part 2, Discovery, AWE website.

18. Aldermaston Report 2003-04

19. IDC HPC User Forum

20. "we expect an additional 30-fold increase in computing capacity over the course of the next decade" - Aldermaston Report 2002; Discovery refers to a 10 year computing strategy to move from 10 to 100 Teraflops systems by the end of the decade - Jim Taylor, History of Scientific Computing at AWE part 2, Discovery, AWE website.

21. IDC HPC User Forum

22. Discovery, the science & technology journal of AWE, March 2000.

23. Nuclear Weapons Campaigns budget FY 2005. p 110-4

24. NIF is "intended to achieve controlled thermonuclear fusion in the laboratory", Nuclear Weapons Campaigns budget FY 2005, p112.

25. NIF is planned to have an energy output of 1.8 Megajoules with 192 beams. www.lasernet-europe.de

26. $468 million of the Ignition program for assessment of thermonuclear burn and $227 million for non-fusion work, Nuclear Weapons Campaigns budget FY 2005 p110-2.

27. Nuclear Weapons Campaigns budget FY 2005, p 82.

28. Campaigns, Nuclear Weapons Budget FY2005, p124.

29. OMEGA has an energy output of 40 kilojoules. www.lasernet-europe.de

30. Flight test FCET –34; Nuclear Weapons Campaigns budget FY 2005. p94

31. AWE annual report 2002; Written answer by Adam Ingram, Hansard 2 March 2004.

32. ORION will have two Optical Parametric Chirped Pulse Amplifiers (OPCPA) Petawatt Kilojoule laser chains on top of 10 long-pulsed multi Kilojoule beams - www.lasernet-europe.de

33. VULCAN has an energy output of 3 kilojoules www.lasernet-europe.de

Annex K
US and NATO Dual Capable Aircraft

Dual Capable Aircraft (DCA) can be used in either a conventional or a nuclear role. Squadrons of F15E, F16 and Tornado aircraft are trained and equipped to carry out both functions. These fall into three categories: US Air Force (USAF) units based in the US, USAF Europe (USAFE) units based in Europe, and units of the German, Italian, Dutch and Belgian Air Forces.

The nuclear bombs deployed for use by these aircraft are the B61-3, B61-4 and B61-10. There are 580 of these bombs in the operational stockpile: 480 in Europe plus 100 in the US. An additional 435 bombs are in the warhead reserve in the US.[1] All the bombs are variable yield: B61-3 (0.3, 1.5, 60 & 170 kiloton), B61-4 (0.3, 1.5, 10 & 45 kiloton) and B61-10 (0.3, 5, 10 & 80 kiloton).[2]

The B61-3 and B61-4 were first produced in 1979. The warheads in the B61-10 were built for Pershing missiles. When Pershing was removed, under the INF treaty, the warheads were repackaged in B61 bomb cases. The reconfigured weapons entered service in 1990. The B61-10 has an additional safety feature, Enhanced Nuclear Detonation Safety (ENDS), which is not present on the B61-3 or B61-4. USAFE procedures for allied use of these bombs refer to all three variants.

In 2002 a dummy bomb was introduced for use in training. This B61-4 Type 3E trainer is used to simulate the B61-3, B61-4 and B61-10.[3] These all use Permissive Action Link (PAL). PAL requires a 6 or 12 figure code to be entered before the bomb can be armed.[4] The B61-4 Type 3E trainer simulates the PAL and other electrical systems in a real bomb. The trainers are used to practice moving the weapons, connecting them to aircraft and arming and disarming them.[5] They play a crucial role in training and qualifying both ground crew and aircrew for nuclear operations.

A second type of dummy bomb is the B61-4 Type 3A. This is a maintenance trainer, which should not be used for movement, or arming exercises. It is likely that this is a mock up of the internal features of a bomb. It is probably used for training personnel in how to inspect weapons and in how to replace Limited Life Components and other parts that are external to the sealed Canned Sub Assembly of a nuclear warhead. A third type of dummy bomb, BDU, is also used in exercises.

Towards the end of the Cold War a new method of storing nuclear bombs was devised, the Weapon Secure Storage and Security System (WS3). This was designed to make the weapons more secure and less vulnerable to a conventional or nuclear attack on the airbase. Rather than storing all the weapons together, a few bombs are placed in a vault in each hanger. Each vault can take four bombs. It is likely that at each airbase at least one vault is kept empty for use in training exercises. The first WS3 vaults were completed in Germany in 1990 and in Turkey in 1998. A recent modernization programme has the target of keeping the facilities operational until 2018.[6]

USAF units based in the US

Tactical aircraft based at two US airfields have the facilities to train for a nuclear role. There are two operational squadrons of F15E at Seymour Johnston Air Force Base (AFB). These aircraft are trained and prepared for worldwide deployment at short notice. There are five Type 3E trainers at Seymour Johnston. The second airfield is Cannon AFB, which has three squadrons of F16 and requires three Type 3E trainers. These aircraft probably have a similar role to those at Seymour Johnston. The aircraft at both bases also train for and are deployed on conventional operations.

There are no Type 3A trainers required at either of these bases. This suggests that there are no nuclear weapons at either site. B61-3, B61-4 and B61-10 bombs are stored at the main USAF nuclear depots at Nellis AFB and Kirtland AFB. Additional weapons may also be stored at depots at Eglin AFB and Sheppard AFB. Many of the bombs at Nellis and Kirtland are part of the US reserve or are awaiting dismantlement.

In 1998 one of the squadrons from Seymour Johnston was trained for a nuclear role and then sent on an exercise, within the US, simulating a nuclear attack on North Korea.[7] Although these units have a potential global role, there has been a particular emphasis in the past on their deployment to Europe in support of NATO. In 1997 regional Commanders were asked if they required support from DCA. Only the Commander of EUCOM said that he did.[8] Aircraft from Seymour Johnston took part in a nuclear exercise in support of NATO in 1998.[9]

USAFE units in Europe

Lakenheath AFB in England is the most significant USAF nuclear base in Europe. It is home to US F15E aircraft and has the largest number of type 3E trainers.[10] There 33 nuclear bomb vaults and an estimated 110 B61 bombs on the site, all allocated to the USAF.[11] There is a smaller capability at Aviano AFB in Italy. This is a base for USAF F16 aircraft. Here there are 18 nuclear bomb vaults and around 50 bombs, allocated to the USAF.

There are substantial number of bombs at Ramstein in Germany and Incirlik in Turkey. No Dual Capable Aircraft are based at either site. Most of these weapons could be used by aircraft from Seymour Johnston and Cannon in the US.

Ramstein AFB in Germany is the main US base in Europe. It houses the headquarters of USAFE and of NATO air operations. There are 55 bomb vaults and it is estimated that there are between 110 and 130 bombs at Ramstein. 90 of these are allocated to the USAF. There is also a requirement for four Type 3E trainers at Ramstein, although there are no aircraft based there which could carry out a nuclear strike role.[12]

At Incirlik AFB in Turkey there are two Type 3A maintenance trainers and 25 bomb vaults. However there is only one Type 3E trainer. This implies that there is no Turkish Airforce or USAF unit based in Turkey, which is certified for a nuclear role. The Bulletin of Atomic Scientist estimates that there are 90 bombs at Incirlik, 50 of which are allocated to the USAF.

Spangdalem AFB is a USAF base in Germany. The unit that is responsible for the maintenance and security of US nuclear weapons has its headquarters at Spangdalem. There do not appear to be any nuclear weapons at Spangdalem. The airfield is the home base for F16s. However the USAF would like to move these aircraft to Incirlik, if Turkey gives permission.[13]

German, Italian, Dutch and Belgian Aircraft

During the Cold War a number of NATO countries were allocated US nuclear weapons. These were kept in US custody, but could be released in war for use by European members of the alliance. A legacy of this deployment has continued in the nuclear capable aircraft maintained by four of the allies.

There are similar capabilities at four airbases: Buechel (Germany), Ghedi (Italy), Kleine Brugel (Belgium) and Volkel (Holland). There are two or more squadrons of strike aircraft at each base. The German and Italian Airforces have Tornado’s and the Belgians and Dutch Airforces have F16s.

Each of these bases has been assigned six Type 3E trainers to practice handling and arming bombs. These airfields each have 11 bomb vaults and one Type 3A maintenance trainer.[14] It is estimated that there are 20 nuclear bombs at each, except Ghedi Torre where there are 40. All the weapons are allocated to the host airforce. Release of the bombs can be authorised by the senior US officer in Europe, either in his NATO role, SACEUR, or as the Commander of US European Command.[15]

Dual Capable Aircraft practice carrying out attacks from another nuclear airbase in the annual NATO exercise ABLE GAIN. In Spring 2004 this was held at Kleine Brugel. Two aircraft from each of the four European Airforces took part, plus two USAF F15s from Lakenheath.[16]

Summary of US nuclear bombs in Europe

The table below shows the likely distribution of B61 bombs, WS3 vaults and bomb trainers in Europe.[17] Dual capable aircraft based at these sites are also shown.

site	country	aircraft	airforce	B61 bombs US use	B61 bombs host use	WS3 vaults	Type 3E trainers	Type 3A trainers
Kleine Brogel	Belgium	F16 C/D	Belgian	0	20	11	6	1
Buchel	Germany	Tornado	German	0	20	11	6	1
Ghedi Torre	Italy	Tornado	Italian	0	40	11	6	1
Volkel	Holland	F16 C/D	Dutch	0	20	11	6	1
Lakenheath	England	F15E	USAF	110	0	33	7	2
Aviano	Italy	F16 C/D	USAF	50	0	18	3	2
Ramstein	Germany			90	40	55	4	2
Ircirlik	Turkey			50	40	25	1	2
Spangdalem	Germany	F16 C/D	USAF	0	0	0	1	1
Total				**300**	**180**	**175**	**40**	**13**

Until 2001 there were also 20 B61 bombs at Araxos Airbase in Greece for use by the Greek Airforce. The table assumes that these were moved to Ramstein AFB.[18] The deployment of trainers in the table is from a 2004 list of requirements. This differed from a proposed distribution drawn up the previous year, which was probably never implemented.[19]

The Bulletin of Atomic Scientists estimates that total number of B61s deployed in Europe in 2004 was 480, the same as it had been in 1994.[20] This is consistent with a graph, on the NATO website, that shows there was no significant change in the number of bombs in Europe between 1999 and 2004 and only a slight reduction between 1993 and 1999.[21] This small drop was probably due to the withdrawal of RAF WE-177 bombs from Germany between 1995 and 1998.

Alert statUs and forward deployment

In 1981 around 5 % of DCA in Europe were on minutes notice to take off and the remainder were on hours or days notice.[22] In 1995 the NATO Nuclear Planning Group reduced the state of readiness, half the force would be on weeks notice and the other half on months notice.[23] In 2002 the alert status was further reduced and the whole force is now on a state of readiness measured in months.[24] Training will be required for participation in annual ABLE GAIN and ABLE ALLY nuclear exercises. With the extended alert status it is possible that only limited additional training is carried out and that only a proportion of the units are actually nuclear certified.

Given this low state of readiness, and concerns about security, it is surprising that the weapons are still forward deployed. They could have been withdrawn to the US, even if they were not scrapped. An article written in 1993 by J Gregory L Schulte, Director of NATO's Nuclear Planning Directorate, gives an insight into this. He dismissed the view that the bombs could be removed and only returned if there was a crisis, saying, "NATO's nuclear posture must seek to dissuade a potential aggressor in peacetime, instead of only after a crisis has begun."[25] The scale of weapons deployed shows that Russia is still considered the main potential aggressor. But the continued forward deployment of B61 bombs only makes it more difficult for Russia to reduce its own nuclear forces. This posture makes Russia more of a risk. Also the more sub-strategic nuclear weapons which Russia retains, the greater is the risk that they could fall into other hands. Keeping the B61s does not contribute to European security but undermines it.

The second point which Mr Schulte made was that if the bombs were moved back to the US, then redeploying them in a time of crisis could exacerbate the situation. This is the same argument which is used to justify keeping Britain's Trident submarines fully armed and on patrol. But yet the US has taken some steps of this nature. Nuclear armed cruise missiles have not been scrapped, but they are no longer deployed. The concept of "responsive force" in the current US posture is based the argument that it is useful to have reserves which are only activated in a crisis. It is hard to accept that fears of reintroducing weapons in a crisis are the real reason behind the failure to withdraw B61s from Europe. Keeping the weapons in place is not a no-risk option, it perpetuates historic fears and increases the risk of an accident.

A more genuine US concern may be that if the weapons were withdrawn their European allies would veto their redeployment during a crisis.[26] This indicates that a key factor behind the continual presence of these bombs is concern in Washington that the Europeans will not always fall in-line behind American military policy. The USAF could technically use bombs based in Britain, Germany or Turkey without the host nation's permission. However this would do irreparable damage to the alliance.

The future of Dual Capable Aircraft

There are safety issues surrounding the handling and movement of nuclear bombs in Europe.[27] There was particular concern about the Greek and Turkish Airforces. Neither has aircraft with a nuclear role today. Inspections revealed that many crews were not properly trained. In a "wartime scramble" things could go wrong. The Type 3E trainers were introduced in response to this.[28]

Maintaining a nuclear role complicates conventional air operations. Procedures for training and certifying crews for a nuclear role are time consuming. The presence of B61 bombs in aircraft hangers imposes restrictions on operations, particularly the handling of conventional explosives, within the building. Similar bombs were withdrawn from South Korea in 1991, despite ongoing concern about North Korea.

B61 bombs are concentrated at between 2 and 4 major storage sites in the US. In Europe they are dispersed in 175 vaults at 9 airbases. While the old concern was theft, the new threat is suicide bombers. A report by Major Lyle Cary USAF addresses the security of these weapons. He regards Europe as a "higher threat area" than the US and urges policy makers to consider whether security considerations outweighed any remaining benefits from keeping the B61s in Europe.[29] He concludes that the bombs should be removed and stored in the US.

The F16 will be phased out when the new F35 Joint Strike Fighter (JSF) is deployed. At this stage there are no plans to develop a nuclear capability for JSF, but the aircraft is being designed so that this capability can be added later.[30] Germany is replacing the Tornado with the Eurofighter between 2007 and 2015 and there are no plans for the new aircraft to have a nuclear role.[31]

In 1997 Air Combat Command suggested that the state of alert of the DCA based in the US should be reduced. The Commander of EUCOM objected.[32] He argued that these forces were still important because Russia had a 3 to 1 advantage in tactical nuclear weapons and were placing increased emphasis on these weapons as their conventional forces declined. He also expressed concern about states that could potentially target WMD on European capitals.

Paul Robinson, Chair of the US Strategic Advisory Group, said that NATO's nuclear-capable aircraft are of limited value against Russia. Their old targets in Eastern Europe have vanished and they would not be able to penetrate Russian air defences. Instead he argued that these aircraft could be an "extremely important component of an Allied force to deter aggression in wider parts of the world".[33] He added that the allies have to be motivated to maintain these forces.[34] In 1994 discussions had been held on procedures for using nuclear weapons based in Europe in the Persian Gulf, which is outside EUCOM's area of responsibility.[35]

However a detailed study into the new forces that the US should acquire for Counter Proliferation concluded that DCA should be retired and the funding diverted to other projects.[36] The USAF is far more likely to use B2 bombers in a Counter Proliferation nuclear attack than DCA. One major constraint on the use of DCA is the requirement for host nation support. Most NATO members are not enthusiastic about US plans to use NATO nuclear weapons for Counter Proliferation. Turkey has said that it would not support US military action against Iran.

The Whither Deterrence study into future nuclear requirements, carried out by Lawrence Livermore Laboratory, concluded that there was no need to retain forward based aircraft in a nuclear strike role and that these forces should be eliminated.[37] A Defence Science Board Task Force on Nuclear Deterrence said, "The long term rationale and support for DCA was uncertain".[38]

Some of the USAF commanders responsible for DCA are concerned about a lack of coherent planning for their potential use. Prior to the drafting of the Doctrine for Joint Nuclear Operations, US Joint Forces Command (USJFCOM) carried out a review of existing procedures.[39] A representative of USJFCOM commented, "USSTRATCOM plans integrating DCA within the various theaters are not very apparent to the units that may be tasked to carry out these plans."[40]

In an academic report Major Brian Polser USAF argues that forward-deployed DCA, on a state of alert measured in months, are not well suited for the new strategic strike role.[41] He says that NATO is schizophrenic in the way it promotes both non-proliferation and nuclear deterrence. The deployment of Theatre Nuclear Weapons in Europe is described as "a strategy in search of a threat". He concludes that the B61s should be withdrawn from Europe. Lee Butler described these weapons as "the most dysfunctional, menacing, and generally counterproductive element in the current relationship [between the US and Russia]".[42]

A study into the Future Roles of US nuclear forces says of the DCA in Europe – “what military problem they could actually solve remains manifestly unclear”.[43] It argues that these weapons could only be used against an opponent who could not be stopped by conventional forces, but who lacked effective air defences. The limited range of the aircraft also restricts the situations in which they might be used. The conclusion is that “The purpose of the United States tactical nuclear weapons currently deployed in Europe is political, not military”.[44] The study identified problems resulting from uncertainty over the role of DCA. If they only serve a political purpose, then it may not be important that the nuclear planners don’t know their job, and the pilots aren’t trained. But, the authors argue, if they have a military role, then this has to be thought through and the appropriate training provided. They further argue that “US planners at least need to know the difference”, they need to be clearly told if these are only political weapons, or if they have any military purpose.[45]

The traditional political argument was that nuclear weapons were a sign of America’s commitment to the defence of Europe. In 2005 there were calls from Belgium and Germany for the bombs to be removed. The US cannot claim it is responding to demands from Europe for nuclear support.

A second argument is that by deploying its own weapons the US reduces the likelihood of European countries building their own bombs. Historically this argument was particularly made with regard to Germany. There is no sign that any European states, apart from Britain and France, have any interest in building their own bomb.

A third factor is that these weapons are retained as bargaining chips, to be negotiated away in exchange for reductions in the Russian tactical nuclear stockpile.[46] Russia does still have a large stockpile of these weapons. But there is no need to delay any reduction in NATO’s equivalent arms. The US and its European allies should take the initiative and unilaterally scrap these weapons.

Notes

1. R Norris & H Kristensen, US Nuclear Forces 2005, Bulletin of Atomic Scientists, January/February 2005.

2. R Norris, H Kristensen & J Handler, The B61 family of bombs, Bulletin of Atomic Scientists, Jan/Feb 2003

3. Nuclear Weapons Procedures, Air Force Instruction 21-2004, 17 February 2004, .

4. The B61-10 requires a 12 digit code, the B61-3 and B61-4 use a 6 digit code.

5. Sandia Laboratories News 18 October 2002

6. BITS press release 29 May 2001. www.bits.de/public/pressreleases/pr290501e.htm

7. H Kristensen, Preemptive Posturing, Bulletin of Atomic Scientists September/October 2002.

8. H Kristinsen, US Nuclear Weapons in Europe, NRDC, 2005, p48

9. ibid p 53

10. Nuclear Weapons Procedures, Air Force Instruction 21-2004, 17 February 2004, .

11. R Norris & H Kristensen, US nuclear weapons in Europe 1954-2004, Bulletin of Atomic Scientists, Vol 60 No 6, Nov/Dec 2004

12. There is also a strange requirement for a B61-0 Type 3E trainer at Ramstein. The B61-0 is no longer in service. Nuclear Weapons Procedures, AFI21-204, 17 February 2004, .

13. www.f-16.net

14. Norris & Kristensen op cit; some other estimates indicate that Volkel has 13 vaults.

15. 717 MUNSS Nuclear Surety Weapons Safety Lesson Plan, 10 Nov 1994

16. www.31tigersqn.be

17. The distribution of bombs is from Norris Kristensen op cit. The allocation of trainers is from Nuclear Weapons Procedures, AFI21-204, 17 February 2004, .

18. Alternatively they may have been moved to Aviano AFB in Italy or returned to the US; Norris & Kristensen op cit

19. The 2003 list would have required no Type 3A trainers in Ghedi Torre or in Volkel and only 2 Type 3E trainers at Kleine Brogel. This suggests that NATO was considering withdrawing bombs from the Italian Air Force base at Ghedi Torre and from Holland and also reducing the number of DCA in Belgium. The 2003 list allocated 5 Type 3A maintenance trainers to Ramstein. This was revised down to 2 trainers in the 2004 version. Annexes to Nuclear Weapons Procedures, AFI21-204, 17 February 2004

20. Norris & Kristensen op cit,

21. NATOs Nuclear Forces in the New Security Environment 3 June 2004

22. ibid

23. ibid & NATO Nuclear Planning Group June 1995, November 1995 and June 1996.

24. NATOs Nuclear Forces in the New Security Environment 3 June 2004 & NATO Nuclear

Planning Group June 2002, and June 2002. The alert status of the DCA based in the US was lowered in 1998 but there is no indication of what that status is. Kristinsen, US Nuclear Weapons in Europe, p48

25. J Gregory L Schulte, NATO's nuclear forces in a changing world, NATO Review, February 1993,

26. Major Brian Polser, Theater Nuclear Weapons in Europe: The Contemporary Debate, USAF, Strategic Insights, September 2004,

27. Failures in inspections of USAF nuclear units were described in W Arkin, The nuclear burden, Bulletin of Atomic Scientists, Jan/Feb 2000 and also in Kristinsen US Nuclear Weapons in Europe

28. Sandia Laboratories News 18 October 2002

29. Major Lyle W Cary, Evaluating US Air Force nuclear weapon storage area security in the post Cold-War environment, USAF, April 2000, Air Command and Staff College

30. Kristinsen, US Nuclear Weapons in Europe, p62

31. ibid, p58f

32. Message from CINCEUCOM on CONUS-based DCA Readiness Requirements, December 1997, quoted in Kristensen, US Nuclear Weapons in Europe.

33. Robinson White Paper

34. ibid

35. Kristensen, US Nuclear Weapons in Europe, p 39. Guidance to cover pre-prepared targeting of DCA outside the Area of Responsibility was to be produced by April 1994, Minutes of NSNF Working Group 29 March 1994. www.nukestrat.org

36. Report of the Defence Science Board Task Force on Future Strategic Strike Forces, February 2004

37. Whither Deterrence, LLNL, 2002, p 33f

38. Defence Science Board Task Force on Nuclear Deterrence, October 1998

39. Message from JFSC to STRATCOM and others on the production and contents of JP 3-12.1, 8 Feb 02.

40. Joint Staff Input to the Doctrine for Joint Nuclear Operations, 28 March 2004.

41. Major Brian Polser USAF, Theater Nuclear Weapons in Europe: The Contemporary Debate, Strategic Insights, September 2004,

42. Schell, op cit p 205

43. Buchan op cit, p 26

44. Buchan op cit, p 26

45. ibid p 104

46. After the Strategic Offensive Reductions Treaty 2002 Donald Rumsfeld and Colin Powell acknowledged that future US-Russian arms discussions must address the issue of Non Strategic Nuclear Weapons.

Abbreviations

The following are abbreviations used at more than one point in this report.

ABM	Anti Ballistic Missile
AFB	Air Force Base
AF&F	Arming Fuzing and Firing System
AWE	Atomic Weapons Establishment
B2	US stealth bomber
B61	US freefall nuclear bomb
CINC	Commander in Chief
DCA	Dual Capable Aircraft
DESS	Data Entry Sub System
DGZ	Desired Ground Zero
ESGN	Electrostatically Supported Giro Navigation
EUCOM	US European Command
FCS	Fire Control System
FOIA	Freedom of Information Act
FY	Financial Year
GPS	Global Positioning Satellite
HEU	Highly Enriched Uranium
ICBM	Inter Continental Ballistic Missile
ISPAN	Integrated Planning & Analysis System, formerly called SWPS
JSCP-N	Joint Strategic Capabilities Plan – Nuclear annex
LANL	Los Alamos National Laboratory
LE	Life Extension
LLNL	Lawrence Livermore National Laboratory
MGPS	Missile Graphic Planning System
MIRV	Multiple Independently Targeted Reentry Vehicle
MoD	Ministry of Defence
NATO	North Atlantic Treaty Organisation
NOTC	Nuclear Operations and Targeting Centre
NPR	Nuclear Posture Review 2001
NSWCDD	Naval Surface Warfare Centre Dahlgren Division
OPLAN	Operations Plan
OPLAN 8044	Main US nuclear war plan, formerly called the SIOP

OSP	Ocean Survey Program
PBV	Post Boost Vehicle
RAF	Royal Air Force
RB	Reentry Body
RNEP	Robust Nuclear Earth Penetrator
RV	Reentry Vehicle
RUSI	Royal United Services Institute
SACEUR	Supreme Allied Commander Europe
SIOP	Single Integrated Operations Plan
SIPS	SLBM Integrated Planning System
SLBM	Submarine Launched Ballistic Missile
SNL	Sandia National Laboratory
SRS	SLBM Retargeting System (Strategic Retargeting System)
SWPS	Strategic War Planning System
STRATCOM	US Strategic Command
TASM	Tactical Air to Surface Missile
TLAM-N	Tactical Land Attack Missile – Nuclear
TNO	Theatre Nuclear Option
UJTL	Universal Joint Task List
UKLC	United Kingdom Liaison Cell
USAF	United States Air Force
USAFE	United States Air Force Europe
W76	Trident warhead
WE-177	RAF freefall nuclear bomb
WMD	Weapon of Mass Destruction
WS3	Weapons Secure Storage and Security System

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