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The Trident Commission

An independent, cross-party inquiry to examine UK nuclear weapons policy

Background papers to the Concluding Report

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BASIC

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This collection of briefing papers is not representative of the views of the Trident Commission but rather of the authors that submitted them. They have fed into the Commission's deliberations and have been affected by them.

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Foreword

The last Labour Government reaffirmed its commitment to the UK's independent nuclear deterrent, based on Trident, at the end of 2006. The current coalition government, in its October 2010 Strategic Defence and Security Review (SDSR), maintained a commitment to this decision in principle but also announced some changes to UK nuclear doctrine, a reduction in the number of warheads and missiles possessed by the United Kingdom, and a delay to the timetable for the construction of the replacement submarines on which the Trident system depends.

The decision to delay the final judgment on replacing the submarines until after the next election has created a window of opportunity for further deliberation on UK nuclear weapons policy. The starting point for the BASIC Trident Commission is a belief that it is important to make the most of this opportunity.

We are living through a period of enormous change in international affairs with new powers and security threats emerging, increased nuclear proliferation risks, and growing pressure on economies and defence budgets in the West. Since the original 2006-07 decision on Trident renewal, modest arms control progress has also been made by the United States and Russia and President Obama has set out a vision of a world free of nuclear weapons. The current government, more recently, has also initiated a further review of possible alternatives to Trident. In our view, there is a strong case in this context for a fundamental, independent, review of UK nuclear weapons policy.

There is also a case, in the national interest, for lifting the issue of the United Kingdom's possession of nuclear weapons out of the day to day party political context and for thinking about it in a cross party forum. The BASIC Trident Commission has been doing this by facilitating, hosting and delivering a credible cross-party expert Commission to examine the issue in depth.

The Commission has been focusing on three questions in particular, namely:

- Should the United Kingdom continue to be a nuclear weapons state?
- If so, is Trident the only or best option for delivering the deterrent?
- What more can and should the United Kingdom do to facilitate faster progress on global nuclear disarmament?

This collection of background papers is published on the same day as the final report from the Commission and can be read alongside it. They are not representative of the views of the Commission but rather of the authors that submitted them. They have fed into the Commission's deliberations and have been affected by them.

The first paper, by Paul Ingram of BASIC and based extensively upon an original longer paper written by Ian Kearns for the Commission, charts the diverse and complex set of threats that face the UK, placing the decision on the renewal of the Trident system in the broader context and its relevance to emerging threats. The paper concludes that in a world with tight budgets and extensive demands, choices need to be made over priorities, international alliances and cross-government co-operation.

The second paper looks at the issue of nuclear deterrence and some of the challenges associated with it. It is important that when investing in our strategic systems for the purpose of deterring potential adversaries we are clear about its effectiveness in doing so.

The third paper looks at the budgetary aspects of the Trident renewal project. Using figures within the public domain, it charts the year-by-year spend and some of its implications. We do not believe that cost should be the determining factor – if there is a strong case for retaining nuclear weapons on security grounds then it is important that we find the resources to pay for them. Nevertheless, this will clearly play an important role in the public debate.

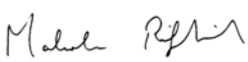
The fourth paper is about threshold status, not an option likely to receive much support in the near future, but nevertheless an inevitable later step if currently nuclear-armed states were to take the road towards full nuclear disarmament. This paper considers some of the key issues that would be faced at these later stages.

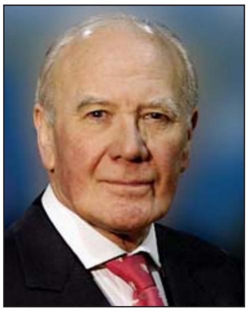
The fifth paper, written by Matt Cavanagh in his personal capacity two years ago for the Commission, surveys alternative platforms and delivery systems for a British nuclear deterrent. It complements the official Trident Alternatives Review published by the government a year ago, and both papers informed the Commission's discussions on its second question.

Alongside the Commission's own final report we hope that these background briefings will stimulate wider discussion as we approach the General Election and the subsequent decisions over the renewal of the UK's nuclear weapon system.

The Co-Chairs

Malcolm Rifkind





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Paper 1
Global strategic security trends and their impacts on UK security

Paul Ingram[1]

Introduction

This paper looks at the broader threat environment the UK faces, containing a wide range of evolving economic, social, demographic, environmental and scientific factors, in order to analyse how relevant the UK's nuclear weapons are to the emerging threats the country faces. Of course future prediction, when the future is unknowable, is an inherently risky business. The one certain thing is that no-one today can tell what threats we will face, the alliance relationships that may pertain, the technology that will be available and deployed in two to three decades from hence. In fact, whatever future does come to pass by 2040 will certainly not have been clearly predicted by anyone. However, it is important in today's complex security environment to attempt some level of transparency over the threat perceptions that influence our thinking.

Closely related to this point, we are often dealing with what scenario-planners would call low probability, high impact events, particularly when it comes to threats for which an independent nuclear deterrent might become relevant. The probability of the UK facing an aggressive Russia alone in the 21st century is very small but of great consequence. It is difficult to accurately assess the probability of such events, not least because of the well-established psychological phenomenon that the very act of focusing upon a small or unlikely event generally leads the mind to over-estimate its probability.[2] Simply because we can imagine a particular scenario does not mean it is likely (but we often think it is). On the other hand, our failure to imagine or predict other possibilities will lead us (obviously) to underestimate their probability.

The allocation of scarce resources to building the capacity to respond to key threats, not only relevant to the Ministry of Defence, but increasingly involving departments across Whitehall, requires the government to consider the relative importance of those threats in the round. The interconnection between threats also demands a joined-up approach. Here we review ten key trends we believe to be of importance to the future security environment, and link these to the specific security challenges likely to face the UK and its allies in the years ahead.

Global trends and observable phenomena

Nuclear dangers

The numbers of nuclear weapons in state inventories have reduced from a peak of around 70,000 warheads in the mid-1980s to about 16,300 today, or which around 4,000 are operational;[3] but nuclear force enhancement programmes are underway in all nuclear-armed states, with the potential to trigger new nuclear arms races.[4] A summary of key elements of each modernisation programme going on outside the UK is presented in the Trident Commission's first briefing paper.[5]

Russia and the United States have recommitted to maintaining a triad of land, sea and air-launched strategic nuclear systems for decades to come. China and India are each seeking to build a nuclear triad, and France has pledged to keep and invest in its nuclear weapons for the long term. India and Pakistan, who have fought three wars in recent decades, are both increasing their nuclear forces and building new plutonium production reactors to expand their warhead production potential. Israel is reputed to be improving the range of their nuclear capabilities, and may well soon have a nuclear-armed submarine. There is little sign in any of these states that a future without nuclear weapons is actively being contemplated, and in the last two decades nuclear weapons have spread to some of the most unstable and security-challenged regions of the world.

Several thousand weapons in the US and Russian arsenals remain on very high states of alert, ready to launch at a few minutes' notice and in some cases to launch on warning (LAW) of a possible incoming attack.[6] Twenty years after the end of the Cold War, this potentially leaves decision-makers minutes, not hours or days, to make decisions on nuclear weapons use.

Beyond the existing nuclear armed states there are, as is well known, serious concerns about further proliferation to countries such as Iran, and possibly as a result concerns over the threat of a regional proliferation cascade in the Middle East. There remain major concerns over North Korean nuclear weapons and their potential to destabilise East Asia.

And there is also a potential threat from nuclear-armed terrorist groups and a major concern that as civil nuclear power expands globally, it may be even more difficult to keep fissile material secure.

In addition, ballistic missile proliferation is a concern especially in relation to Iran and North Korea, with the fear in relation to both countries being that, at some point in the future, each will have global reach with long-range land-based missiles.

Emergence of other technologies

Emerging technologies such as artificial intelligence, robotics, next-generation information technology, advanced web applications and quantum computing, and miniaturised weapons have security implications that are as yet unpredictable. What is clear is that all societies are increasingly dependent upon networked, often space-based, information and communication technologies, exposing every system to new vulnerabilities, both in cyber and outer space. It is also pointing to a future in which new kinds of weapons are going to be used.

The step-changes in the development of military technology have always had a major impact on the outcome of conflicts. With each introduction of major new technology, opponents have warned of dire consequences; the emergence of nuclear weapons was only the most obvious of these. Today, the increasing prevalence of attack drones, robots and automated weapons bring a special shift in warfare that could both lower the threshold for conflict, and expand further its impact on civilians within theatre. Controlling drones and robots brings its own stress and shifts in the moral decision-making over conflict.[7] Currently these technologies are largely held and used by states allied to, or close to, the United Kingdom, but this is all about to change, with unpredictable impacts.

Cyber-attacks on military, governmental and civil infrastructure targets are already occurring and will become more sophisticated in future. The generalised attack on Estonia in 2007 and the more specific and more recent Stuxnet attack on Iranian nuclear facilities in 2011 illustrate their potential. Future space-based weapons, capable of striking targets in orbit and on the ground, could be technically feasible and may even be widespread by 2040.[8]

With regard to biotechnology, much the same knowledge that can be used to cure disease can also be used to create bio-weapons. The capability of relatively low-qualified scientists and technicians to use technologies for malign purposes is expanding rapidly.

The British Medical Association, among others, has warned in this context that the practical ability to prevent the manufacture and release of harmful biological agents, and even recognition of the need to do so, has not kept pace with scientific developments. A synthetic version of the polio virus has already been produced; were the same to happen with smallpox, it could cause breakdowns in social order and challenge international security organisations like the North Atlantic Treaty Organisation (NATO) and the United Nations.[9] Containment would have huge economic impacts.

The emergence of these technologies, and their influence on the nature of conflict over power and resources, suggest that there could well be a transition happening that will reduce the relevance of nuclear weapons, and particularly large boomer ballistic missile submarines.

Shift to multi-polarity

Whilst the US military remains dominant, power is shared and balanced between more states in the international system. We are witnessing a massive and historic shift of relative power from the Atlantic seaboard primarily to Asia and the Pacific.[10] Countries such as China, India and Brazil have expanded their share of world economic output along with their demand for energy and minerals, further empowering another group of energy and mineral rich states in the Middle East, Russia, the Caspian Region, Central Asia and North Africa.[11] Analysts of the international environment expect this broad power shift to continue and to usher in a genuinely multi-polar world before mid-century.

Trends in 'terrorist' activity

Violent non-state actors have generally extended their organizational reach, developed and sustained more cross-border connections, and opened new channels through which to radicalise individuals. According to the global terrorism database, the number of recorded incidents they classed as 'terrorist attacks' has gone up markedly over the last decade, though the trend in associated fatalities is less stark.[12]

Al Qaeda affiliates and similar networks continue to exploit ungoverned areas within Afghanistan and Pakistan, Yemen, the Sahel and parts of North Africa. The MoD Development, Concepts and Doctrine Centre (DCDC) assessment of the strategic environment out to 2040 also noted that: 'many of the conflicts and disputes exploited by international terrorist organisations show no signs of early resolution and, out to 2040, international terrorism will persist.'[13]

A rising concern since the attacks of 9/11 surrounds the possibility of non-state use of WMD. Al Qaeda and its offshoots have already demonstrated a grim determination to intensify the destructive force and potential loss of life.[14] Though the probability of their success is difficult to judge accurately, the impact of their acquiring and using nuclear weapons is potentially so large as to make the threat impossible to ignore.

Trends in transnational crime

Transnational criminal gangs are often focused on drug, people and small arms trafficking, financial and cyber-crime, and piracy. One UN estimate of the size of the illicit global market in drugs, people and small arms alone came to over US $350 billion.[15] In countries such as Afghanistan, illicit drug operations have financed insurgency, undermined the authority of central government, and destabilised neighbouring states like Pakistan and Iran. Some serious analysts have pointed to extensive operational overlaps and collaboration between the terrorists and organised criminals, and future terrorist acquisition of chemical, biological or radiological components is likely to come through organised crime groups.

Patterns of violent conflict

The number of intra-state or non-state conflicts remains high, resulting in massive population displacement. In 2011, 26.4 million people were classified as internally displaced by violent conflicts of one kind or another.[16]

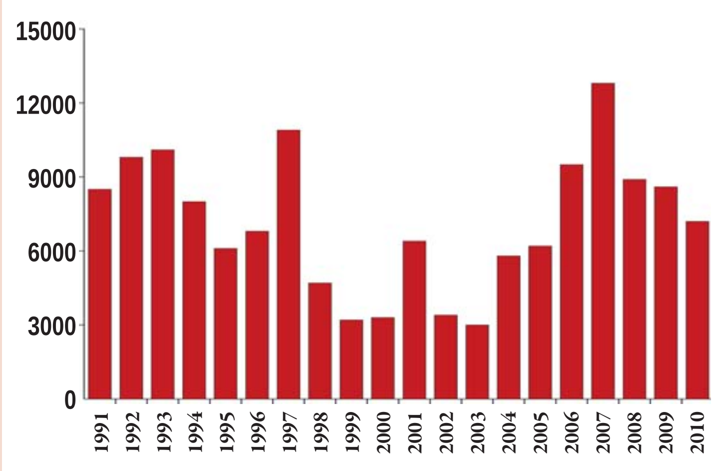
Prevalence of weak and failing states

Weak and failing states in the international system outnumber stable and sustainable ones by more than two to one.[17] This presents consequences for international security as terrorist groups and criminal gangs seek to take advantage of states with governance challenges.

Demographic change

UN projections suggest that the global population will reach 9.2 billion by 2050, an increase of almost 40 per cent in 40 years.[18] Population growth will change power balances in the international system and deepen international competition for scarce resources. Demand for food and energy may rise by up to 50% and water by up to 30% by 2030.[19] The 'Arab Awakening' over the last two years is symptomatic of the rising awareness of regional and global inequalities likely to upset established orders. By 2050, some 2 billion people will be living in slum conditions.[20] 'Mega-cities', with over 10 million inhabitants, will have particular governance challenges, and be 'centres of criminality and disaffection' and 'focal points for extremist ideologies'.[21]

Global violent attacks by non-state actors



Source: National Consortium for the Study of Terrorism and Responses to Terrorism

Poverty and inequality

The vast majority of the human race will, for decades to come, continue to live in difficult conditions in the developing world, leading some to talk of a 'marginalised majority world'.[22] The pervasive nature of today's global media and communications technology makes the inequalities that exist all the more visible, driving ideologies that tap into any associated sense of injustice.[23]

Climate change

Climate change will serve as a multiplier of some of the other security trends and threats already described. China warned in its first official report on climate change in 2006 of a possible future food production crisis, with as much as a one-third decrease of crop yields to be expected by 2030.[24] Dependent upon economic growth to sustain one party rule, this could push the government into more repressive measures at home and more nationalistic policies abroad to shore up its legitimacy. Overall, however, it is in the developing world and the Middle East where climate change is likely to add extra stress to already fragile states and lead to massive migration, and add new flash points to already difficult relationships.[25]

Overall implications for global security

The trends reviewed are suggestive of the kind of future international security environment that policy-makers may have to deal with: major power shifts, huge population pressures, persistent and visible problems of poverty and inequality, conflict and state failure on the one hand, and more power in the hands of non-state actors, new domains of conflict and new types of weaponry on the other.

On the upside, despite or because of mounting pressures, a more cooperative international atmosphere is possible, as states overcome their differences and come together to address the threats and risks beyond the reach of any one of them. Climate change, nuclear disarmament, nuclear proliferation, terrorism and transnational crime, for example, are all challenges that can only be successfully met collaboratively and with cross-border action.

Economic interdependence relies on complex physical and virtual infrastructures that can be disrupted and therefore need to be defended. Air and sea lanes, major ports, rail and road infrastructure, telecommunications links, gas and oil pipelines, manufacturing and energy supply facilities are the lifeblood of the world economy. Protecting them is increasingly a multilateral activity since break-downs in one part of the system can have serious negative knock-on effects in others.[26]

It is equally and perhaps more likely, however, that the result of the trends and phenomena outlined in this chapter will be increased uncertainty, instability and conflict in international affairs and major challenges to any effort to sustain and grow a rules-based international system. This is not inevitable, of course, and the goal of policy should surely be to avoid it, but there are a number of reasons to approach the future with caution.

Threats to a cooperative global system

Potential return of power politics

The rise of countries such as India and China, and the assertiveness of Russia, are emblematic of a wider and important change to the structure of the international system. Multi-polarity in an open world generates competition. Major power shifts now underway could bring conflict, perhaps by miscalculation if not by policy design, as new rivalries emerge and older rivalries perhaps re-surface. The larger powers are conscious of this danger, as China's emphasis on a 'peaceful rise' illustrates; but the pressures could become unmanageable, and already we see a shift towards a more assertive approach taken by China in its near abroad. Important flashpoints include the Taiwan-China relationship, multi-party disputes over potentially resource rich territorial claims in the South China Sea, and geostrategic competition involving China, the United States and India in the Indian Ocean.[27]

Trust undermined by nuclear weapons

The continued possession of nuclear weapons and particularly the maintenance of substantial arsenals on short notice to fire years after the end of the Cold War are not only symbols of distrust, but they directly undermine the creation of the trust and other necessary elements of a cooperative global system. As part of the project to create the conditions to facilitate moves towards a world free of nuclear weapons, there need to be significant further developments in international institutions, a transparent willingness on the part of Great Powers to exercise self-restraint, and a change in the narratives that surround threat and security.

Possible competition and conflict over resources

The growing world population and climate change impacts will cause greater competition over resources.[28] China, Russia and the EU are all vying for access to energy supplies in Central Asia and the Caucasus. The United States and China are competing to secure important oil, gas and natural mineral resources in Africa. The Arctic is also emerging as a significant global source of fossil fuels and strategic minerals.[29] This competition gives added impetus for states to create the international frameworks to arbitrate these potential disputes, but this will take visionary international leadership, and it seems equally likely that it could destroy the goodwill necessary to such collaboration if the situation is not handled extremely carefully.

Disturbances in pivotal regions

Another possible danger concerns disturbances in 'pivotal regions' of disproportionate importance to the world economy. The further destabilisation of any of the key states within the Arabian Peninsula would provide opportunities for ideological extremists, raise the likelihood of instability in neighbouring states, and impact upon both global supplies of oil and global shipping routes running through the Red Sea and the Strait of Hormuz.[30] Greater instability, if it comes in such areas, will bring severe consequences to the international system as a whole.[31]

Threats to UK markets and external supplies

It is also possible that competition over resources could help to fragment global markets and lead to increasing protectionist pressures in the international system.'[32] Barriers to trade, capital flows and migration, if introduced in a widespread way, would be likely to lead to more inter-state trade disputes and the possible emergence of regional blocs, each containing a number of states coalescing around one or more of the major powers.

As an open economy, major financial centre, and global transport hub, the UK is heavily affected by the ups and downs of globalisation.[33] The UK's economic and financial market interests were badly affected by the global financial and banking crises. As a major trading country, the UK is also highly vulnerable to disruptions to global trade, and for that reason has an interest in piracy and maritime trade disruption in pivotal regions such as in the Straits of Hormuz, the Red Sea and the Malacca Straits.[34] Becoming more heavily dependent on energy imports, the UK is further vulnerable to interruptions in supply.
With limited gas storage capacity (around 14 days' consumption), and an increasing reliance upon imports, the UK is more vulnerable to price fluctuations and disruptions of supplies from Russia and other exporting states.[35]

Future oil and gas production will be increasingly concentrated in non-member Organisation for Economic Co-operation and Development (OECD) countries in the Middle East, Russia, Central Africa and increasingly Africa, so that any conflict and instability in or involving these regions may have very direct impacts on UK energy supplies and/or on the price to be paid for those supplies. These dynamics also impact upon other important commodities. Decisions by exporters to withhold rare earth metals, for example, could undermine certain strategic industrial sectors in the UK, such as the military technology or low carbon sectors.[36]

Threats to the Euro-Atlantic region and to core allies

The UK's allies in NATO and the EU face similar threats and vulnerabilities as the UK: terrorism, cyber-attack, interruptions to energy supplies and trade. Many of these are shared threats. To the east, the big issue remains the uncertain nature of the NATO and EU relationship with a Russia that appears to be becoming both more authoritarian and xenophobic and, on occasion, more assertive, partly as a consequence of its lack of confidence in its environment. It is clear that Russia will continue to oppose NATO expansion, and will remain highly likely to seek privileged influence in the Baltic States, Ukraine, the Caucasus and Central Asia, and to dominate much of the Arctic, which it sees as central to its long-term prosperity. At the same time, it could build on strong energy links with some EU states and, barring a transformation of the current uncertain relationship into a more cooperative one, to use these links occasionally to attempt to disrupt NATO and EU coherence in the near future.

Russia retains a very large nuclear arsenal, of comparable size to the United States. Continued tensions and disagreements with Russia over prevailing military dispositions in the Euro-Atlantic region, and over the difficulties in making further arms control progress, both nuclear and conventional, remain. The latest, resulting in Russia's annexation of Crimea and instability in eastern Ukraine, has been widely seen as an important step towards a longer-term confrontation. This may deepen mistrust in the relationship if not addressed, and leave the continent of Europe with a dangerous unresolved Cold War legacy, a potentially expensive distraction from engagement with the emerging powers and from challenges of wider 21st century international politics. A key uncertainty when considering the future of the UK's nuclear deterrent revolves around the trajectory of Russian foreign policy and associated nuclear and conventional posture. Indeed, of all the future threats that the UK could face for which a nuclear deterrent could have relevance, this one would seem the most convincing.

To Europe's south, the wave of change sweeping North Africa and the Middle East, often centred on the disaffected young populations of the region, remains a major source of uncertainty that may yet lead to regimes less friendly to the West, to more weak or failed states, and to opportunities for terrorists and criminal gangs to exploit. It may also lead, along with the effects of climate change in sub-Saharan Africa, to waves of northward migration as young populations seek to escape conflict zones and the attendant lack of real economic opportunity. This could create a significant challenge as Europe struggles both to support those in the region trying to tackle the problems at source and to secure its own southern borders. But it is not, in itself, relevant to a future UK strategic deterrent.

On the other hand, the possibility of nuclear and missile proliferation in the Middle East, centred for the time being on Iran but suggesting further proliferation pressures elsewhere in the region, is a more particular worry, if challenges to the existing world order could emerge from states possessing a nuclear deterrent as a back-up to their claims. This is a concern for all NATO states but perhaps especially, given its geographic location, to Turkey. It is possible that NATO will at some point forge a nuclear deterrent relationship with an evolving Iran, though this is probably some way off and could be multi-polar and unstable. It would also not be strongly relevant to an independent British strategic deterrent unless the outlook and strategy of the United States were to change dramatically and strategic European defence were to fall more heavily upon European states.

The rise of new powers in Asia and the Pacific, and the projected growth of the US domestic Hispanic population, means the strategic focus of the United States is shifting from Europe toward Asia and Latin America, which could in the long term threaten the political rationale of NATO.[37] European members of NATO and other EU states will need to consider how they can better provide for their own security in the context of the current economic crisis sweeping the continent, and in light of Europe's longer-term demographic and economic growth challenges. In the light of austerity and continual pressures on defence budgets for the foreseeable future, recent European cut-backs in defence capabilities are likely to continue. Some, including US officials, have been reported to suggest that this ought to cause pause for thought in both the UK and France on whether or not to invest in the next generation of nuclear weapons systems rather than alternative conventional capabilities.

The on-going process of civil and military technological diffusion to Asia is affecting relative capabilities and the global trade in sophisticated defence equipment, and is degrading the UK's ability to intervene, notwithstanding the likely increase in the desire to do so for all the reasons outlined earlier.[38] Future intervention operations will have to be multifaceted, combining elements of hard and soft power, and elements of high intensity combat with post-conflict stabilization and human security operations. Wars 'among the people', resembling in some respects the counter-insurgency operation currently winding down in Afghanistan, will likely reoccur, at some considerable financial and human cost. Alternative means to intervene that create fewer unintended consequences will have to be further developed.

It may be that major power conflicts are limited in intensity and scope in future but take on the form of wars between proxy states or organisations, at least some of which will not always act in predictable ways.[39] Future conflicts are also likely to have a hybrid character involving combined use of conventional, irregular, and high-end asymmetric methods.[40] Phenomena such as cyber-attacks to degrade an opponent's capabilities may therefore become much more common but also more difficult to attribute to an aggressor, and therefore to deter in future.[41] Across the entire conflict environment, whole new classes of weapons based on biological and synthetic agents should also be expected, and may be combined with novel delivery systems aimed at targeting not only people but materials and crops.[42]

The UK and its core allies are therefore likely to face a highly challenging and complex conflict environment in future, with the potential for malign combinations. This will place heavy demands for considered policy responses to greater diversity and complexity and more collaborative working. It will demand significant investment not only in traditional military capabilities but also in strengthening the resilience of the UK's infrastructure and other forms of protection against emerging threats. This is going to have to be handled alongside a re-working of established burden-sharing arrangements in NATO to compensate for the shifting focus and role of the United States. In a time of highly-constrained budgets, it will not be possible to respond to these shifting priorities unless decisions are taken to prioritise capabilities relevant to the twenty-first century.

Endnotes for Paper 1

1 Paul Ingram is the Executive Director of the British American Security Information Council (BASIC), and runs the Secretariat in support of the Trident Commission process. This paper is based on an original draft prepared by Ian Kearns two years ago for the Commission, and draws extensively on several of the more recent and comprehensive attempts to survey the future global strategic environment, including the IPPR Commission on National Security in the 21st Century (www.ippr.org/security), the work of the Defence Concepts and Doctrine Centre (DCDC) of the UK Ministry of Defence and its 'Global Strategic Trends: Out to 2040' report in particular, and the US National Intelligence Council's unclassified review of the world out to 2025 (http://www.aicpa.org/research/cpahorizons2025/globalforces/downloadabledocuments/globaltrends.pdf). We have also drawn on relevant evidence received directly by the Commission in the course of its work; for written evidence to the Commission (www.basicint.org/tridentcommission/evidencereceived).

2 This phenomenon has been widely researched by psychologists, and is best explained here: Daniel Kahneman, 'Thinking, Fast and Slow', 2012.

3 Figures at the start of 2014 according to the Stockholm International Peace Research Institute, 'Nuclear Forces Development' in *SIPRI Yearbook 2014,* Oxford University Press, Oxford 2014, http://www.sipri.org/research/armaments/nuclear-forces

4 For a country by country review of modernisation programmes in the nuclear armed states and a discussion of the security rationale for nuclear weapon possession in each one of them, see Ian Kearns, Beyond the UK: Trends in the Other Nuclear Armed States, BASIC Trident Commission Discussion paper Number 1.
http://www.basicint.org/sites/default/files/commission-briefing1.pdf

5 Ian Kearns, 'Beyond the UK: Trends in the Other Nuclear Armed States', Discussion Paper 1 of the BASIC Trident Commission, BASIC, November 2011, Table 1, pp. 4-5. http://www.basicint.org/sites/default/files/commission-briefing1.pdf

6 Given the flight time between Russia and the United States for an ICBM is well under an hour; launch under attack requires very rapid decision-making.

7 See, for example, Christopher Coker, 'Technology is making man the weakest link in warfare', *Financial Times*, 9 May 2013: 'Pilots may become supervisors and drones may become robots'.

8 CDC Strategic Trends Programme, 'Global Strategic Trends: Out to 2040', Ministry of Defence, Fourth Edition, 2010, p.156.

9 The Atlantic Storm exercise, which involved policy-makers such as former US Secretary of State Madeleine Albright, simulated the release of the small-pox virus, initially in Europe. The scenario saw the first affected states invoking Article V of NATO as a route to accessing vaccine stockpiles in other member states, only to be denied as the disease spreads and individual member states seek to hang on to what vaccine stockpiles they have. See www.atlantic-storm.org for more details.

10 See, IPPR National Security Commission, 'Shared Destinies, the interim report of the IPPR Commission on National Security', IPPR, November 2008, p.26, http://www.ippr.org/publications/shared-destinies-security-in-a-globalised-world

11 Global Strategic Trends: Out to 2040, Ministry of Defence, January 2010, p.10.

12 To see the graph at source see: http://www.economist.com/blogs/dailychart/2011/09/global-terrorism-deaths

13 DCDC Strategic Trends Programme, 'Global Strategic Trends: Out to 2040', Ministry of Defence, Fourth Edition, January 2010, p.32.

14 See Lawrence Freedman, ed., 'Superterrorism: Policy Responses', London, Blackwell, 2002.

15 UN Office on Drugs and Crime, 'World Drug Report', United Nations, 2007.

16 See 'Internal Displacement Global Overview 2011: People Internally Displaced by Conflict and Violence', IDMC and NRC, April 2012, http://www.internal-displacement.org/publications/global-overview-2011.pdf

17 See http://www.fundforpeace.org/global/library/cfsir1210-failedstatesindex2012-06p.pdf pp.4/5. See Failed States Index 2008, available at:
www.foreignpolicy.com/story/cms.php?story_id+4350

18 See Shared Destinies: The interim report of the IPPR Commission on National Security, 2008, p.32.

19 IPPR, Shared Destinies, p.17.

20 DCDC Strategic Trends Programme, 'Global Strategic Trends: Out to 2040', Ministry of Defence, Fourth Edition, 2010, January 2010, p. 12.

21 Shared Destinies, the interim report of the IPPR Commission on National Security, IPPR, 2008, p.35. 'There are around 20 of these 'megacities' today and their number is projected to increase to 27 by 2025.' Quotes from Global Strategic Trends - Out to 2040, MoD, January 2010, p. 12.

22 See in particular the work of the Oxford Research Group, www.oxfordresearchgroup.org.uk

23 The MoD's review of strategic trends out to 2040 puts it this way: 'grievance, in the face of continued inequality and highlighted by pervasive global communications, may result in a revival of Communism, especially if it evolves and dissociates itself from the failures of the Soviet Union… nationalism will remain a powerful force… Far right ideologies may see a revival… Influential religiously and philosophically inspired ideologies, linked to Islam and Confucianism, may also emerge'. See 'Global Strategic Trends - Out to 2040', MoD, 2010, p.45.

24 See J. Li, 'China Releases First National Report on Climate Change', World Watch Institute, January 11, 2007.

25 IPPR Shared Destinies, pp.40-43.

26 'Global Strategic Trends - Out to 2040', MoD, January 2010, p.11.

27 See 'Global Strategic Trends - Out to 2040', pp. 50-52.

28 'Global Strategic Trends - Out to 2040', p.25/26.

29 'Global Strategic Trends - Out to 2040', p.33.

30 'Global Strategic Trends - Out to 2040', p.60.

31 'Global Strategic Trends - Out to 2040', p.41.

32 'Global Strategic Trends - Out to 2040', p.10.

33 See 'A Strong UK in an Age of Uncertainty: The National Security Strategy', HMG, October 2010, CM 7953, p.3.

34 See 'Global Strategic Trends - Out to 2040', p.64.

35 Robin Webster, 'The Carbon Brief', 25 March 2013. Available here: http://www.carbonbrief.org/blog/2013/03/uk-gasstorage-and-energy-prices

36 'Global Strategic Trends - Out to 2040', p.18.

37 'Global Strategic Trends - Out to 2040', p.131.

38 'Global Strategic Trends - Out to 2040', p.79.

39 'Global Strategic Trends - Out to 2040', p.14.

40 'Global Strategic Trends - Out to 2040', p.13.

41 'Global Strategic Trends - Out to 2040', p.150.

42 'Global Strategic Trends - Out to 2040', p.145.

Paper 2
The relevance of deterrence

Paul Ingram[1]

Salience of nuclear deterrence

Is the UK nuclear deterrent still relevant today?

The UK's nuclear posture grew out of a particular situation in the mid-twentieth century, first in relationship with the United States and the Manhattan Project during the Second World War, and then in the emergence of the Cold War with the Soviet Union. It was clear who the adversary was, and the nuclear arsenals involved were developed within the specific context of the strategic and ideological conflict at that time. The UK provided a second point of decision, complicating the calculations of the Soviets and strengthening the credibility of NATO's nuclear umbrella over Europe in the context of conventional inferiority and a growing Soviet nuclear arsenal that dwarfed that of the UK. The British nuclear forces were sized in order to ensure a high confidence in the ability of UK forces operating alone to cause sufficient damage in a second strike to deter the Soviet Union from any conceivable action they might contemplate.

Since the Cold War the government has focused on maintaining a nuclear deterrent capability in case of the re-emergence of any such threat. The 2006 White Paper put it:

> *In terms of their destructive power, nuclear weapons pose a uniquely terrible threat and consequently have a capability to deter acts of aggression that is of a completely different scale to any other form of deterrence. Nuclear weapons remain a necessary element of the capability we need to deter threats from others possessing nuclear weapons.*[2]

General deterrence clearly remains a relevant strategy to all states that could face adversaries willing to use coercion against them. But the implication of the government statement above is that the deterrent effect is somehow proportional to the destructive power of the weapons used to deter, and that this in turn needs to be proportional to the level of threat. Whilst this has intuitive appeal, it depends upon several assumptions. Deterrence works by holding at risk things that an adversary values sufficiently highly that they choose not to engage in an attack.

For deterrence to be effective, the damage to the objects of value multiplied by the probability of inflicting that damage must be greater than the benefit to be had by the aggressor multiplied by the probability of realising that benefit. Important to note here is that there is no direct relationship with the destructive power held by the aggressor, or specifically its holdings of nuclear weapons.[3] An aggressor may have overwhelming superiority in all forms of military capability, but if both sides believe that the defender possesses sufficient capability to inflict unacceptable damage with sufficient probability then the deterrent relationship is stable. It is not always necessary to possess nuclear weapons to deter the possible threat of a nuclear attack.

For deterrence to be effective it needs to be linked not only to a capability to do general damage, but to credibly threaten damage specifically to things of value. In most cases nuclear weapons are not credible because they are too large and unwieldy, and leaderships would only begin to contemplate using them in the most extreme cases.[4]

Is it possible to talk of a deterrent capability separate from particular adversaries? Deterrence is not directly about the capability fielded but rather the impact on the calculations of the particular aggressor. This means there are additional complexities when attempting to maintain a generic overwhelming but very blunt capability of mass destruction on the basis that it could prove a useful deterrent against some possible future adversary. Whilst many believe that possessing a nuclear arsenal played a critical role in deterring a Soviet advance in Europe in the 20th century, future confrontations will take on very different forms, for which nuclear weapons may not have relevance. This question led the Commons Defence Committee to recommend in February 2007 (just before Parliament's vote on the renewal of Trident the following month) that *'the Government should do more to explain what the concept of deterrence means in today's strategic environment'*.[5]

Challenges within nuclear deterrence

Nuclear deterrence has always had problematic elements within its logic. Any deterrent threat is less credible when there is doubt about the resolve to carry out that threat on the basis that it appears unacceptable or disproportional, or if there are more acceptable means at one's disposal.

Conceiving the circumstances for which we would use nuclear weapons has always been a challenge. Yet any weakness of resolve to launch a nuclear attack weakens the essence of nuclear deterrence. It requires a certain reputation of sticking with the stated policy, even if it appears irrational to do so.

Joseph Nye described the situation during the Cold War as the first major confrontation in which all those involved knew that the final endgame, if it went all the way, would be thermonuclear exchange. Both sides prepared to do the unthinkable, and prepared to act irrationally, in order to achieve some form of stability. But for all that stability it had its dangers.

Nuclear deterrence depends upon clear and unambiguous signalling that is picked up and absorbed by any potential aggressor. In a crisis, signalling often becomes foggy and imprecise. What may appear in the cold light of day as a clear signal of intent can easily be misinterpreted under rapid decision-making and intense psychological pressure. Add to this the possibility of break-down in command and control, and the results can be disastrous. The Cold War had its fair share of mistakes, near-misses and miscalculations, and there would be little guarantee that the emergence of any future nuclear rivalry would end in quite the same manner. Could we really have a similar level of confidence (itself far from solid during the bi-polar Cold War) in a multi-polar world with fewer weapons in more hands and a greater variety of strategic cultures and objectives?

Nuclear weapons are very effective in creating very large and destructive explosions that devastate large areas and kill large numbers of unprotected civilians. But this tactic is not a very effective strategy in winning wars. It was not the large scale city bombing of cities in the Second World War that determined the outcome of the conflict; indeed, such actions may simply have deepened the resolve of the populace to support their leaders in resisting the enemy. The narrative that the bombing of Hiroshima and Nagasaki forced Japan to surrender has communicated the power that nuclear weapons have in intimidating an utterly unreasonable enemy into submission. But new evidence suggests that it may not have been the bombings that broke Japan, but rather the entry of Russia into the war and its forces overwhelming Japanese defences to the north.[6] It may not sound intuitively right, but the use of nuclear weapons to destroy cities may not affect the outcome of a conflict; it may simply re-enforce the will and brutality of one's adversary in response.

Declining salience of nuclear weapons?

Nuclear deterrence has not prevented significant conflict involving nuclear armed states in several cases during the 20th century: Argentina attacked the Falkland Islands in 1982,[7] the Arab states attacked Israel in 1973, and Iraq attacked Israeli cities with Scud missiles in 1991. With changes in strategic, economic and social relationships and the development of alternative military technologies and the nature of conflict, the established nuclear weapon states may have a vanishingly small set of circumstances in which they would seriously consider using nuclear weapons. The immediate fear of nuclear attack has largely subsided; though some talk of a potential resurgence in the relevance of nuclear weapons with the Ukraine crisis, this is far too premature. Some have termed this the deepening nuclear taboo, a dynamic feedback loop that undermines future public support for investment in nuclear deterrence, as long as nuclear weapons continue to appear irrelevant to outcomes. Such as it exists, the taboo has gained ground the longer nuclear weapons have remained unused, weakening the salience of nuclear deterrence (as deterrence relies upon the credible intention to use nuclear weapons in certain circumstances), and states have started to look for other more usable military and policy tools to implement deterrence in all but the most extreme circumstances.

It has also meant the development of new nuclear missions beyond strategic deterrence. NATO evolved the doctrine of flexible response in the Cold War – that nuclear weapons could be used in a tactical role to 'de-escalate' a situation where the other side may be tempted to press home an advantage in its conventional capabilities by using a limited nuclear strike. Today Russia uses this concept to justify its continued attachment to tactical nuclear weapons. More recently the US Bush Administration proposed in its 2002 Nuclear Posture Review the development of 'bunker-busting' nuclear weapons to target deeply-buried targets or the destruction of WMD stores. Military strategists were reported to have considered the use of nuclear weapons against Al Qaeda forces sheltering in caves in Afghanistan, though this was probably an empty threat as executing it would have been a major own goal in the propaganda battle against Al Qaeda, because of the nuclear taboo.

This raises an additional, perhaps even more potent, contemporary doubt about continued dependence on nuclear deterrence and its implied threat of the use of nuclear weapons against large population centres. There is increasing concern over the spread of nuclear weapon technologies, and the potential for so-called 'rogue states' or non-state actors to acquire nuclear weapon capabilities.

This has led a growing number of opinion-shapers and military leaders to conclude that we urgently need to escape our dependency on nuclear deterrence for global stability and shore up the measures to prevent proliferation of sensitive technology before deterrence breaks down and nuclear weapons are used.

Insurance policy of last resort

Doubts remain, however, all the more so with an increasingly belligerent Russia. Could an aggressor emerge with an assertive foreign policy and the capability to engage in nuclear blackmail? These doubts have been playing out in recent debates within NATO over its new Strategic Concept (adopted in 2010) and its Deterrence and Defence Posture Review (concluded in 2012). Because of their history and geographic proximity, there is a fear within central and eastern Europe that if NATO were to lower its nuclear guard, perhaps by withdrawing its remaining B61 nuclear bombs from Europe, this could embolden the Russians, not to attack NATO, but to intimidate and bully those smaller front line states in its near abroad by using other economic and social means or more violent but underhanded means.

In his introduction to the 2006 Defence White Paper announcing the government's decision to pursue a renewal of the Trident system, Prime Minister Tony Blair said:

> *'We believe that an independent British nuclear deterrent is an essential part of our insurance against the uncertainties and risks of the future.'*[8]

Later, when leading for the government in the debate on the decision in Parliament on 14 March, Foreign Secretary Margaret Beckett said: 'There's the potential for a new nuclear threat to emerge or to re-emerge... Maintaining a nuclear deterrent remains a premium worth paying as an insurance policy for this nation'. And it is this concept of the insurance policy that forms the principal public reason given for the UK's investment in renewing its nuclear deterrent.[9]

Describing the UK's nuclear arsenal as an insurance against any possible degrading security environment and the emergence of a threat to the UK is not new, though the analogy is not a perfect fit. Insurance is taken out in order to receive financial compensation to make up for any loss. By contrast, retaining a nuclear capability for the possibility of deterring a possible future threat that could emerge is more about a future capacity to reduce the probability of attack or coercion than compensation in the event.[10] Nevertheless, the analogy is close enough to have meaning to the public, who themselves have to take out insurance against all sorts of risk.

As a framing device, insurance also communicates the idea that investing in the system is the only responsible action; those in our society who do not insure against risk are generally seen as reckless. A government that failed to invest in systems generally perceived as a necessary insurance for foreseeable scenarios would be seen as weak on defence, particularly irresponsible and unworthy of public support, and could lose legitimacy. This is all the more relevant given the long lead-times in acquiring nuclear systems, so that decisions to get out of the game entirely are seen as effectively irreversible, and therefore a decision that is effectively imposed upon future governments.

The idea of an insurance policy of last resort is a powerful one, and clearly applies to a threat from a known enemy with nuclear capability. But this insurance policy is far less effective against general uncertainty, or even against threats from future nuclear-armed states with an unconventional view of their own vulnerability or deterrent relationship with other states, or from non-state actors. Such threats will need security investment of a different kind.

Are there alternatives to nuclear deterrence?

Deterrence with conventional capabilities

There are still no military means of matching nuclear weapons for their sheer destructive power. This does not always mean they are the only or even the most effective means to hold at risk the objects of value for an aggressor. Because there will always be some level of doubt as to the willingness to use nuclear weapons even in the most extreme circumstances because of their scale of impact, the horror of their use, and the international opprobrium that follows it, in most circumstances the nuclear threat does not directly impact upon strategic deterrence. Their residual use is believed to be in preventing any potential escalation of threat beyond that for which other means may be insufficient. This potential escalation possibility is extremely difficult to predict, one way or another.

It is very dangerous for a state to rely too heavily upon nuclear deterrence exclusively for its deterrent capability against actively aggressive states that may be stronger in other areas. If there is a large gap between its conventional and nuclear deterrence capabilities, it runs the danger of its nuclear bluff being called in the space between its capability to inflict damage with its conventional military and that circumstance when its very existence is called into question.

Strategists have attempted to overcome this problem by describing postures that use one or two smaller or tactical nuclear weapons in a manner that deescalates a crisis by showing resolve. Such tactics have not until now been put to the test, but during the Cold War there was considerable doubt that such a tactic could be actually deployed and limited to one or two nuclear bursts, and is a doubt that continues today. So a state that possesses nuclear weapons still needs also to possess sufficient conventional capabilities for other deterrence purposes. In other words, nuclear weapons are no safe or reliable substitute for conventional capability.

'Deterrence by denial' (defence)

Deterrence is essentially altering the balance of cost-benefit for a potential aggressor, usually by increasing the cost to them of their aggression. Deterrence by denial reduces or eliminates the ability of the aggressor to press home their attack and thereby deters them from trying in the first place. If a state knew that it were unlikely to have the ability to accurately land a missile on another's capital because of missile defences for example, this would discourage them from considering such an action in the first place.

In the age of nuclear weapon and missile proliferation, deterrence by denial centres upon the development of air and missile defences. Technologies for defence and offence: forms of detection and the development of stealthiness, have come a long way since the days when radar played a key role in the Second World War. Aircraft and cruise missiles have long been vulnerable to defences, requiring a part of their strategy to be to overwhelm any defences by scale. It is only recently however, with massive spending on the part of the US government, that the promise of defences against long-range ballistic missiles has become a possibility. These remain highly controversial, however, in both their utility and their destabilising impact upon strategic balances. There has in the past been greater European scepticism over the possibilities of breakthrough, but this has not stopped NATO member states to prioritise cooperation over the development of missile defence, in the context of the Obama Administration's Phased Adaptive Approach, stages 1 to 3. This involves missile interceptors based upon Aegis class ships or on land with an advertised ability to intercept a handful of missiles coming from the Middle East towards Europe and the United States.

Even if such a missile defence system eventually is able to intercept such a limited ballistic missile attack (and the technology at present is not persuasive), this would have little relevance against a more overwhelming missile threat, and therefore does not cover the type of threat that a UK nuclear weapons system has up to now been designed to deter. Strategic defence is likely to play a marginal role in strengthening overall deterrence capabilities, rather than change the game entirely.

Interdependence

Globalisation has a number of features, including deepening economic and social inter-dependencies, the free movement of capital and people. With it, traditional forms of military attack and deterrence by punishment becomes more problematic. It makes less sense to destroy one's own investments, markets, sources of critical resources or expatriates. The most obvious and successful effort to actively use this strategy of deepening interdependence to reduce the likelihood of war has been the formation of the European Economic Communities after the Second World War, but the impact does not necessarily need such a coordinated effort. Though the competition may be just as fierce, outright war in future between the United States and China may be less likely as a result of the opening up of China to the West in recent decades, and the level of mutual investment and trade. There is, of course, no guarantee that the nuclear deterrent relationship will yet be neutralised by such dynamics, but it has less salience in a world of increasing globalisation.

Are the alternatives sufficient?

Ultimately, the pivotal question may be whether we are yet ready to conclude that there are no likely circumstances where nuclear weapons would reliably deter when all other means fail.

In the minds of some defence strategists we may be some time away from nuclear weapons losing salience all together. Whilst the military trends may be towards smarter precision weapons used against particular targets, there may yet emerge threats for which conventional weaponry, even the most sophisticated, may be insufficient in providing effective deterrent capability. Because of the deep horror of nuclear weapons, they may play a stronger role in deterring, even if the aggressor would believe there would only be a small chance of their being used.

Recent events in the Ukraine may also give many pause for thought even though they have no direct relevance to nuclear weapons. It may also not take the actual use of nuclear weapons for the current trend to reverse – relationships between nuclear powers may deteriorate dramatically or new less predictable actors join the game.

It is likely to take the concerted and deliberate development of deeper, well-established mechanisms governing interactions between states, and the development of alternative international norms and narratives around the resolution of international disputes, before states will be ready to abandon strategic deterrence as the backbone of their national security.

Endnotes for Paper 2

1 Paul Ingram is the Executive Director of the British American Security Information Council (BASIC), and led the secretariat servicing the Trident Commission 2011-14.

2 'The Future of the United Kingdom's Nuclear Deterrent: the White Paper,' 2006, House of Commons Defence Committee, CM 6994, paragraph 3-3, p.17, http://www.publications.parliament.uk/pa/cm200607/cmselect/cmdfence/225/225i.pdf

3 The government's own Trident Alternatives Review states that any necessary deterrence capability 'does not depend on the scale of military capability that a potential aggressor possesses'; 'Trident Alternatives Review (TAR),' Cabinet Office, July 2013, paragraph 1.6, p.13, https://www.gov.uk/government/publications/trident-alternatives-review

4 Evidence to the Trident Commission: Quaker Action St. Andrews (QUASTA), Nuclear Information Service, and Ward Wilson.

5 The Future of the UK's Strategic Nuclear Deterrent: the White Paper, House of Commons Defence Committee HC 225-1, February 2007, Para 74, p.30.

6 Evidence to the Trident Commission: Ward Wilson.

7 Evidence to the Trident Commission: General Sir Hugh Beach.

8 'The Future of the United Kingdom's Nuclear Deterrent: the White Paper', 2006, House of Commons Defence Committee, CM 6994, Introduction by Tony Blair, p.5, http://www.publications.parliament.uk/pa/cm200607/cmselect/cmdfence/225/225i.pdf

9 Evidence to the Trident Commission, submitted by Peter Cannon, Henry Jackson Society, June 2012.

10 Rebecca Johnson *et al,* 'Worse than Irrelevant: British Nuclear Weapons in the 21st Century', Acronym Institute, 2006.

Paper 3
Measuring the financial costs

Paul Ingram[1]

Introduction

Financial costs should not be the determining feature of an issue as important as whether the UK retains a nuclear weapons arsenal in the 21st century – it is more about Britain's place in the world, its national security and how this relates to global and human security. Nevertheless, financial costs do have a role in determining choices, and in any case will probably feature heavily in the upcoming political debate likely over the next year in particular because of the political atmosphere around austerity and cuts to public spending. This paper, drawing upon data available in the public realm and estimating where it is not available, outlines the costs of the current plans to renew the UK's nuclear arsenal, specifically replacing the four Vanguard-class submarines under the current posture. The figures used for future expenditure should be treated as illustrative estimates.

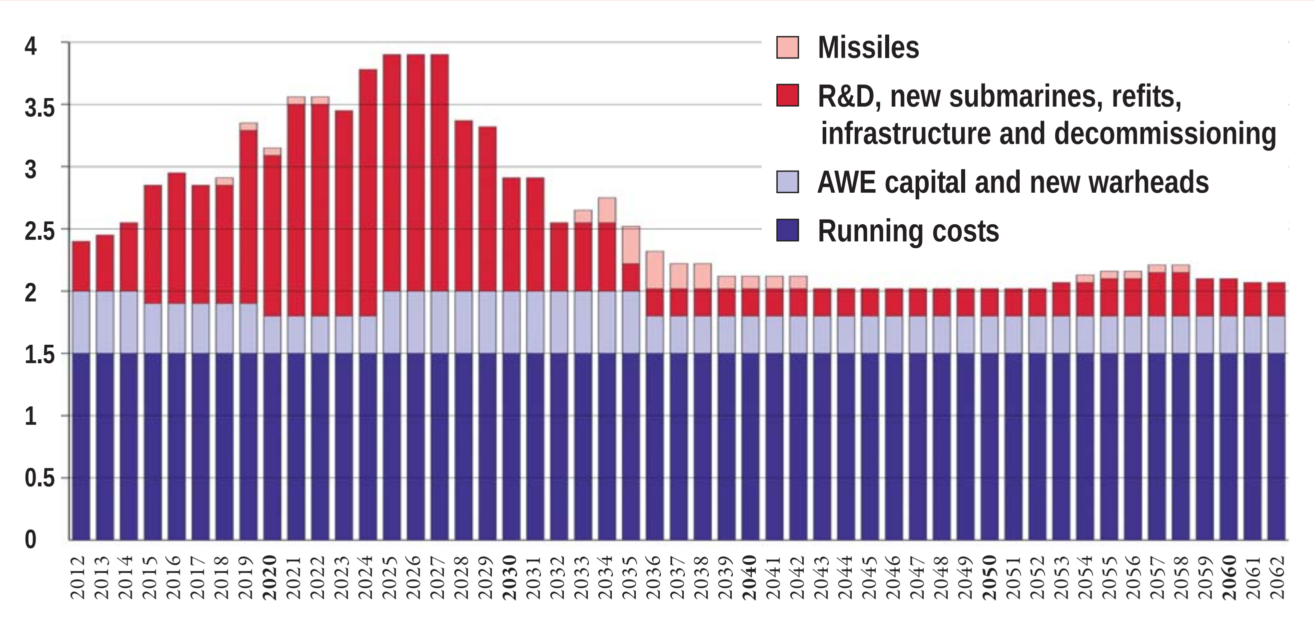
On the surface, estimating costs may seem like a simple task, but a number of factors, not least boundary issues, the incomplete nature of data in the public domain, and risk factors, make it much more complex.

Recent experiences of cost over-runs and delays highlight the fact that costs by their nature involve heroic assumptions, even when replacing systems with which the MoD has a good deal of familiarity. Nuclear weapons systems are perhaps the most complex and expensive systems of any government procurement, have the longest lead-times and perhaps the most stringent assurance requirements. There are significant challenges in assessing costs in an environment of bespoke innovation, technology that is specific and without clear reference, and a future of uncertain requirements.

There have been a number of attempts to estimate an overall budgetary cost for renewing the system and maintaining a British nuclear weapon capability into the 2060s, reviewed briefly here. It clearly requires ball-park estimates of the direct costs associated with the production and running costs of the warheads, missiles, platforms and infrastructure, as well as the indirect costs of protecting the fleet, and other support measures, many of these costs landing in a lumpy fashion through the lifetime of the project. The purchase of submarines is only part of the broader decision to buy into a particular set of systems that form the nuclear weapon capability of the UK.

The general estimated year-by-year cost, assuming a similar system will replace the existing one, looks like this:

Spending profile on current plans [2]



Source: 2012 prices, based upon a variety of sources and estimated figures for which more detail is available in the Commission background paper number 3 published alongside this report.

Recent cost estimates

There have been several recent attempts to estimate the lifetime cost of the follow-on system. The Liberal Democrats in September 2006 estimated a capital and operating cost for the Successor system as £76 billion over its development and 30 year deployment lifetime.[3] In 2009 Greenpeace estimated it to be at least £97 billion.[4] The BASIC Trident Commission's second briefing authored by defence economist Keith Hartley in March 2012 estimated a total cost of some £89.6 billion.[5]

These single figures for the overall cost have not generally involved a deflator (to discount future costs) as normally required by government in estimating costs of major projects. A 2007 BASIC report applied such a discount rate to future costs and added them to the annual running costs to come up with an equivalent annual cost over the operational life of the Successor system of £4.5 billion (in 2012 prices; £3.9 billion in 2006 prices).[6]

Now that the Treasury has decided that the costs of capitalising the Successor systems falls squarely within the MoD budget, there are necessarily significant opportunity costs for other defence systems at a time of tightening belts over the budget over the decade from 2016. These choices over extremely expensive, major procurement projects will impact on the UK's capability to defend itself and operate strategically in the world.

Austerity

Differences over the management of the economy, and in particular, the public sector finances, play a central role in British politics. After the 2009 budget, the Institute for Fiscal Studies predicted 'a decade of pain' for the UK economy and public finances, saying that the government must close a £90 billion black hole to achieve budgetary balance.[7] Public Sector net debt, as a percentage of GDP, has doubled from 36.7% in 2007/8 to 74.5% in March 2014.[8] Net borrowing in 2013/14 totalled £107.7 billion.[9] Added pressures, such as an ageing population and reduced oil tax revenues, mean that most predictions assume a tight rein on the public finances for some time to come.

The Chancellor's decision in the summer of 2010 to require the Ministry of Defence to carry the budgetary burden of the Trident renewal programme was controversial within government. Military decision-makers have generally seen the nuclear deterrent as a political weapon: its intent is to have a political deterrent effect rather than be decisive in battle, and the decision on its use would be down to political rather than military decision-makers.

Whilst this distinction has appeal, it is also limited. Military activity has always been political in nature (war is diplomacy by other means), and military tactics have always had political dimensions.

In any case, the distinction has been used to argue that the investment in new nuclear weapon systems ought not to come at the expense of conventional capabilities. Indeed, this was an explicit commitment made by Prime Minister Tony Blair when introducing the White Paper to the House of Commons in December 2006.[10] At the time this seemed an exceptionally courageous promise, and difficult to validate (would the government explicitly include within future increases in the defence budget allocations to cover the capital expenditure of the renewal programme?), but Members of Parliament appeared to take it at face value. The 1997 Comprehensive Spending Round contained an implication that the defence budget was raised to partially pay for the initial years of concept development – but was greeted by vociferous and coordinated criticism from former military chiefs in the House of Lords who anticipated a real cut in the budget allocation to conventional capabilities.[11] With a change of government to one strongly committed to cuts in public spending of historic proportions as their first and defining priority, the cuts in the defence budget (8.6% over the five years of the Parliament), combined with the instruction that MoD was to find all future capitalisation costs from within its own budget, was to dwarf any implied cuts announced in 2007.

It was clear that the MoD already had an equipment procurement challenge well before defence cuts were contemplated. The June 2011 Levene Review described a 'conspiracy of optimism' within MoD.[12] The SDSR and Spending Review in October 2010 soon after the new government came to power was premised on the urgent need to make difficult choices in defence spending, stating 'our national security depends upon our economic security and vice versa'.[13] It estimated the gap at £38 billion over the decade, assuming a zero-growth defence budget in real terms, though some thought the reality a lot worse. The equipment programme was later re-costed and a further £13.5 billion was added, £8 billion of which was for Trident renewal (now coming from within the defence budget), leading to an average total gap of over £5 billion a year, even at a steady-state defence budget.[14] Taking account of later cuts to the defence budget, Malcolm Chalmers of RUSI estimated that:

> *Out of a projected ten-year funding gap of £74 billion, almost two-thirds (£47 billion) is a result of cuts in the projected Ministry of Defence budget, including a real terms cut of 8.6 per cent between 2010/11 and 2014/15.*

The remainder (£27 billion) is a result of inherited commitments that were unaffordable even if the core budget had continued the rate of growth [1.1% growth per annum] that it had enjoyed since 1999.[15]

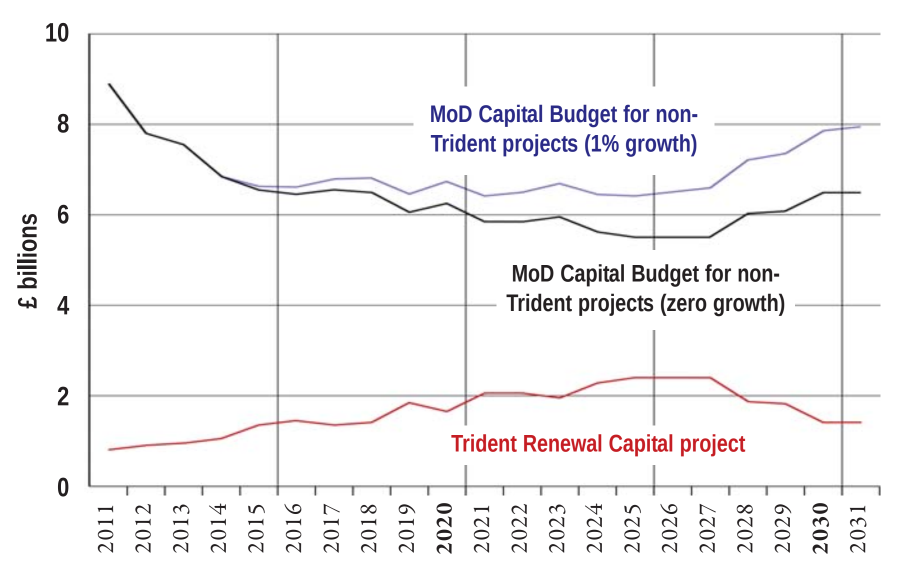
The MoD began dramatic cutbacks on spending and equipment plans, so that by May 2012, Defence Secretary Philip Hammond was able to say that future equipment plans were in balance.[16] In the recent 2014/5 settlement the Ministry had to bear a further £1 billion cuts in real terms or around 3.4% of the total Departmental Expenditure Limit.[17]

This has required heavy and controversial cuts to defence capabilities announced across the board, including in the number of regular service personnel of around 20% by 2020 and 30% reductions in support staff (25,000) by 2015.[18] The Navy has decommissioned HMS Ark Royal early, so that it no longer has any carriers in service, has reduced its frigate orders by four, and decommissioned its Bay-class amphibious support ship. The capital budget was to take a hit of 18.5% over the following three years, putting a big squeeze on high profile projects – some dropped, others pared back or delayed. Malcolm Chalmers of RUSI points out that the prospects of the MoD in keeping control of its equipment spend depend in large part on control in costs of three major projects: the Successor nuclear deterrent, the Joint Strike Fighter, and the Type-26 frigate.[19]

The MoD is planning for an annual real increase in the capital budget of 1% from this year, though this is contingent on the settlement in the follow-on 2015 SDSR soon after the next General Election. This is of a similar order in the rate of increase to that in the defence capital budget in the years prior to the cuts. Recent government statements suggest that the squeeze on public finances will continue well into the next Parliament and that MoD would do well to control their expectations.

The following graph shows the current spending profile on capital renewal for the UK's nuclear weapon systems against the MoD's capital budget on this (optimistic) assumption, as well as that for a steady-state. It includes the estimated spend on the new submarines, missiles, warheads and Atomic Weapons Establishment (AWE) infrastructure outlined below.

Trident renewal impact on the MoD capital budget



Source: MoD capital budget estimates based upon Public Expenditure Statistical Analysis 2013, Departmental Expenditure Limits in real terms, HM Treasury, tables 1.4 and 1.9, www.gov.uk/government/uploads/system/uploads/attachment_data/file/223600/public_expenditure_statistical_analyses_2013.pdf. Capital spending upon Trident project based upon estimates.

Opportunity costs

Money spent on the Trident renewal project is money not then available for other public investments. It is understandable for people to make sense of the amount of spending by reference to alternative spending, particularly other defence procurement projects.[20] It is important to remember that there is no particular obligation on the part of the government or any future government to spend in any particular area; it could simply reduce overall government spending. Nevertheless, the Chancellor has already determined in 2010 that the costs of Trident renewal will come from the defence procurement budget, so it is reasonable to consider the proportion of the budget being consumed by the project, and to compare this with the other major projects also in the pipeline.

The combination of cuts in the MoD capital budget and the spend upon the Trident renewal programme mean that the budget for non-Trident projects under a 1% increase hovers between £6 and £7 billion throughout the 2020s, and between £5 and £6 billion under a steady budget, significantly lower than the £9 billion in 2011. This could put these projects at risk.

The National Audit Office's (NAO) annual Major Projects Report recorded in February 2014 that the 11 major defence projects that they considered were forecast to cost £55.6 billion in procurement (a combined increase of £6.1 billion in the estimates since these projects were individually approved, or 12.3%).

We include the latest forecast cost of the demonstration and manufacture phases of eight of these projects here for illustrative purposes:[21]

- £2.8 billion for heavy lift A400M aircraft to provide tactical and strategic mobility
- £9.4 billion for seven Astute attack class nuclear submarines
- £11.4 billion for Future Strategic Tanker Aircraft (Air-to-Air refuelling and passengers)
- £2.5 billion for Lightning II (Fighter/attack aircraft)
- £6.1 billion for the Carrier Programme (not including aircraft)
- £18.1 billion for Typhoon aircraft
- £1.4 billion to improve the Warrior Armoured Fighting Vehicles

Some of these projects will be complete by the time the peak of spending on Trident renewal takes place, but other security-related projects (in and outside MoD) currently near the head the pipeline and more uncertain at this point will be competing for attention.

Running costs for the system

Outline of current costs

The MoD estimated in 2010 that the 'in-service' costs of maintaining the nuclear deterrent were 5-6% of the defence cash budget.[22] Rt Hon Des Browne, when Defence Secretary stated in October 2007 that the MoD expected to spend £1.7 billion (£1.8 billion 2012 prices) in running costs of the nuclear weapon system in 2010. This was broken down as £950 million on nuclear weapon infrastructure and £750 million on the Vanguard submarine fleet and supporting naval infrastructure.[23] The Navy has additional costs in devoting conventional resources to protecting the Vanguard submarines and contingent forces.

In the 2007 BASIC report, it was estimated to be in the region of £509 million (2012 prices), based upon historical written Parliamentary answers.[24] However, spending in this area appears to have reduced since the original government estimates in 1998 on which this figure was based, in response to a lower threat level. In 2007, HMG estimated the annual operating cost of committed support forces in the order of £28-33 million annually, and that of contingent conventional force elements to be around £280-330 million (though these have a range of alternative tasks in addition, so that it might be appropriate to apply around a third of this figure to the estimate).[25] Adding an additional 50% to the £130 million to cover capital costs of these operations, leads to an illustrative annual figure of £200 million.

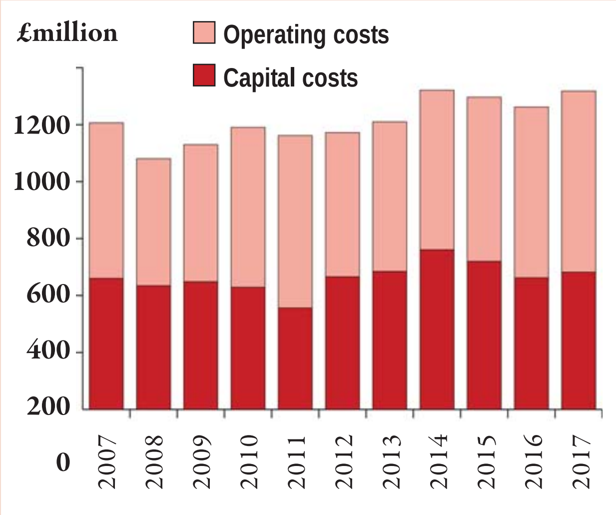
The £950 million figure for the nuclear weapon infrastructure may be a little misleading because it appears to include capital costs that were £410 million in 2010 (2010 prices), an ongoing extension of the programme of work announced in 2005, and which might be more appropriately ascribed to the capital costs of the renewal programme.[26] Running costs for AWE appeared to expand significantly in 2010 and 2011, but projections bring down the running costs to around £510 million a year (2012 prices) from then on.

Running costs accounts

Vanguard & naval infrastructure	£769m
AWE running costs	£510m
Additional naval protection & contingency	£200m
TOTAL	**£1,479m**

The following graph shows AWE's costs in 2012 prices:

AWE annual costs: capital & operating [27]



Source: Commons written answer Peter Luff to Caroline Lucas, 19 June 2012, Hansard, Column 932W. Original figures in outturn prices; these in 2012 figures.

Government estimates for future running costs of both the existing and the follow-on system assume they will sit within this range, namely the 5-6% of the cash budget. However, MoD acknowledges that the running costs of the current submarine system are likely to rise as the system ages, much as annual maintenance costs to keep older cars on the road rise.

Though MoD is likely to have acquired significantly better data on this from the experience of recent refits at Devonport, there is still significant uncertainty about the costs associated with both the life extension programme that will be necessary to keep the Vanguard class at sea for as long as envisaged by the SDSR, and the increasing costs of maintenance in their final years. The October 2010 Value for Money review stated that its delays to procurement would require 'some additional refurbishment of the Vanguard Class... to bridge the gap'.[28] We include notional figures for this in the capital costs section.

It is also difficult at this stage to assess the likely running costs of the new system. The 2006 White Paper made the assumption that running costs would be similar to those under the Vanguard class, and without appropriate historical data to compare with past experience, and a number of factors that could impact in either direction, it is an assumption that will have to hold for our purposes.

Capital costs for renewal

According to the MoD's Initial Gate report, 'The programme to replace the nuclear deterrent is one of the largest and most complex the MOD has undertaken'.[29]

Successor submarines

The conclusions to the 2010 Value for Money review of the Trident Successor project involved a reduction in requirements and an acceptable slippage in the timetable for the production of the submarines, as well as efficiency improvements and investment in life extension of the existing submarines and infrastructure. The Submarine Enterprise Performance Programme (SEPP) across the whole submarine sector was judged to have the potential to save £879 million on the Successor project over the decade from 2011. The government also secured a guarantee from Babcock (Faslane, Devonport and Rosyth) to achieve cost savings of more than £1.2 billion over the next decade. However, the decision that delayed the Initial Gate report in 2011 – namely to procure a new generation nuclear reactor propulsion plant, the PWR3 – added considerable costs to the project, raising some uncertainty as to whether it could possibly remain within the window of costs it had outlined in the 2007 White Paper (£15.0 billion to £17.9 billion in 2012 prices), as it claimed it could in the 2011 Initial Gate report.

In a market where technology has such a significant impact between generations of equipment, with newer versions so much more capable than their predecessors, the comparisons necessary to estimate real inflation are challenging, and throw up a big range of estimates for inflation.

Professor Keith Hartley of the University of York estimates that defence equipment unit costs have been rising at about 10 per cent per year above consumer inflation – unit prices more than doubling in real terms every decade.[30] The NAO recently estimated defence inflation to be 2.7% above consumer inflation.[31] Factors that will also impact upon the costs include evolution in submarine technology and the industry itself, uncertainty over the tax treatment, the tendency to under-estimate capital costs early in a project and exchange rate fluctuations when many of the contracts will be in dollars. Indeed, it was favourable fluctuations in the dollar-sterling exchange that is widely credited amongst other factors for ensuring that the Vanguard submarines came in on budget. There can be no such expectation this time around.

One very basic rule of thumb based on past experience with similar generational replacements would suggest that new weapons systems tend to cost around twice as much as their predecessors. For example, the acquisition cost to the United States of the Poseidon C-3 missile system (in service 1971) was $13.9 billion in 1996 prices, while the cost of the Trident II D-5 (in service in 1990) was $30 billion - just over a doubling of cost over 20 years. The US Virginia class nuclear attack submarine (first boat ordered in 1998) cost $2.1 billion, an increase in real unit cost over the preceding Los Angeles-class by a factor of around 1.9, over a period of 27 years. Double the Vanguard-class would give a cost of £23-25 billion in 2012 prices for the Successor submarines.[32]

The US Ohio-replacement plans are projected to cost $90.4 billion (£57.6 billion) for the construction of a dozen submarines of some similarity to the UK Successor submarine.[33] The US Government Accountability Office (GAO) reports that research and development will cost $11.1 billion (£7.1 billion) and that procurement will cost $79.3 billion (£50.5 billion). The Congressional Research Service reports that there will be $4.5 billion (£2.9 billion) spent on final detailed design and tooling up engineering costs for the first boat, and then $7.2 billion (£4.6 billion) spent constructing it.[34] Following an acquisition review, the Navy has set a target cost for each follow-on boat at $5.3 billion (£3.4 billion), though so far they have only managed to bring the expected cost down to $6.1 billion (£3.9 billion), and describe the target as 'aggressive'. If the UK were to spend a similar amount on R&D and tooling up, but only purchase four boats, then overall costs would amount to £26.3 billion in 2012 prices.

This chapter uses a figure of £22 billion as a conservative estimate, close to the government's published estimates, though we consider it likely the cost could amount to more than this.

The cost of construction of the submarines after main gate is therefore estimated to be in the region of £18 billion (spending prior to main gate is expected to weigh in at £3.9 billion).[35]

The original life-expectancy of the Vanguard class was 25 years. In the 2006 White Paper it was assumed that this could be extended with refits to 30 years. This was extended a further three years in the value for money review leading up to the SDSR. For the purposes of this study we assume a life expectancy for future SSBNs to be 35 years.

Missiles

The 2006 White Paper included a decision to buy into the US life extension project for the existing D5 missile pool, at a cost of £250 million. This will maintain the existing pool of missiles up to 2042, with replacement by its missile successor projected to begin in the late 2020s to be deployed in the new SSBN(X) submarine programme. It seems highly likely that the UK will decide to buy into the US pool of new missiles, and that a future US Administration will agree to this. There have been no estimates at this stage of the cost of these new missile purchases, but if the UK is lucky enough to negotiate a similar package to that involved in buying into the current Trident missile pool (a significant assumption, as the UK paid no development costs for the missiles), then it could expect to pay around the order of £40 million a missile, though it may look to purchase fewer than the 58 missiles it did for the existing Trident system (as there will be a lower requirement). This study estimates a cost of buying into the future missile pool to be £2.0 billion spread over ten years from 2033. The Treasury published in August 2006 year-on-year figures for the cost of the current set of missiles in answer to a Freedom of Information request, and these are reproduced in the graph below translated into 2012 prices, with a total cost of £1.78 billion:

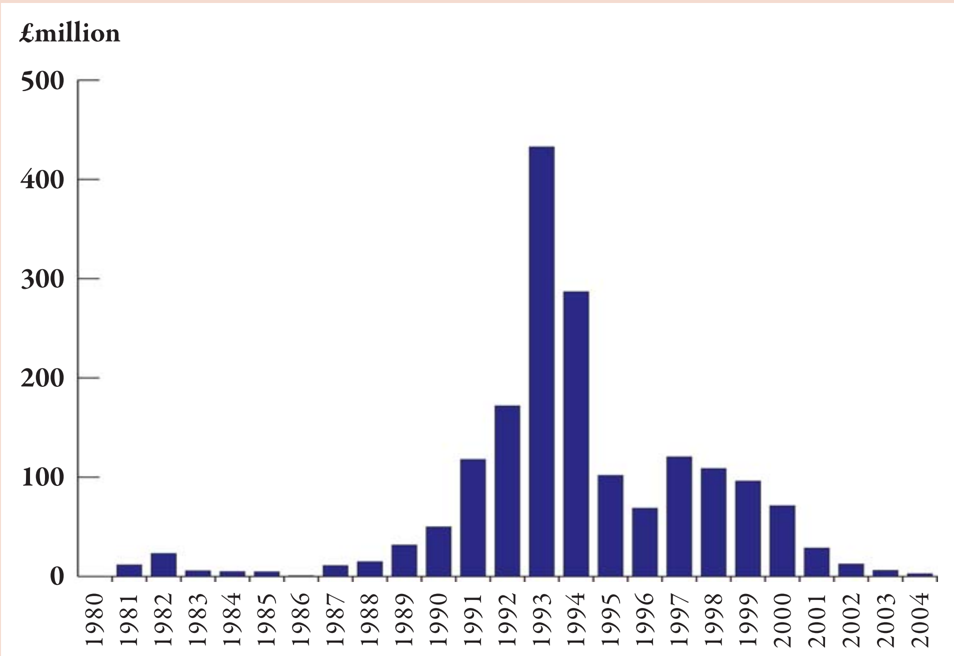
Warheads

Even before any new or modified warhead programme is contemplated, AWE's annual capital costs are set to stick at around £400 million for the near future at least, and then to tail off once this current round of infrastructure investment is completed, to an average £200 million a year until the next set of major investments. Because of a favourable review of the safety and reliability of the current warhead, it was announced in the Strategic Defence and Security Review of 2010 that it would be possible to delay a decision on whether a new warhead was required after 2016. Once the decision is taken to invest in a new or modified warhead these annual costs are likely to rise by several hundred million a year, amounting to an estimated additional £3-4 billion (officially) over the decade from 2025.[36] There is some uncertainty around these costs for a new or life-extended warhead, and they may turn out significantly more than this.

Facilities

There has been significant investment in the naval facilities in support of the submarines since they were constructed in the 1980s. It has been claimed that 'approximately 90% by value of the necessary facilities at Barrow, Devonport and Clyde (Faslane & Coulport) have been recapitalised during the last 20 years',[37] a situation that allowed the government to decide in 2010 to push back any further capital works, with the exception of the £1.1 billion works agreed for the Core Production Capability at Rolls Royce in Raynesway, Derby, thus contributing to the estimated savings announced in the Value for Money Review.

Cost of UK purchase of Trident D5 missiles



Source: HM Treasury, FoI response August 2006.

However, from 2014 it is now likely that significant investment over the next decade will be required to upgrade some facilities.

As already mentioned, the Vanguard class will require additional life extension to facilitate the delay to the acquisition of the Successor submarine. In March the government announced an unplanned additional refuelling of HMS Vanguard as a result of uncertainty over the core reactor's aging.[38] Whilst the Successor submarine will be using PWR3 technology, so that mid-life refuelling will not be necessary, there will still be some necessary mid-life investment in the submarines in the 2040s. The cost of this is completely speculative and has been left out of this calculation.

Capital costs accounts for the planned system (2012-2062)

Successor submarines	£22.0 billion
Refits to Vanguard & infrastructure	£9.6 billion
Missiles – Life Extension Program and successor	£2.3 billion
AWE capital & new warheads	£16.7 billion
Total	**£50.6 billion**

This spending happens in a lumpy fashion over the lifetime of the project, in a cost structure that when combined with the running costs looks like the graph on the first page of this paper. The Net Present Value of this total spend from 2012 to 2060 (capital alongside running costs after 2028 for the new system), applying the government's preferred discount value for each year's spending to account for the value HM Treasury attaches to present, as opposed to future, consumption, comes to £57.6 billion.[39]

This Net Present Value can be annualised over the operational lifetime of the new Successor submarines (to 2062) using the government's discount factor of 3.5% (3% beyond 30 years) to give an Equivalent Annual Cost (EAC) today of £2.9 billion each year of operation. The EAC is the notional, discounted annual value over the operational life to pay for the capital and running costs of the new system, in 2012 prices. Putting this figure in context, with a defence budget today of the order of £32 billion, this equivalent annual cost amounts to 9%.

Decommissioning costs

There is a widely-held assumption in some circles that the decommissioning costs for the Trident system were Britain to abandon its facilities would be at least as great as the current running costs and planned capital costs. There is no publicly available information to back up this claim. It is more likely that the costs of decommissioning will not show a spike, whatever decisions are taken, as this is a process that takes place over many years and deals with legacy systems that have to be decommissioned whether new systems are needed or not.

Currently, the government has no final disposal solution for its nuclear submarines. Old submarines are partially dismantled, non-nuclear components recycled, their reactor cores removed and stored in cooling ponds at Sellafield indefinitely, whilst the hulls and reactors are sealed and maintained afloat in port, at Rosyth and Devonport.[40] The government estimates the current decommissioning liability for redundant and current in-service submarines to be of the order of £1 billion, which suggests an annual expenditure in perpetuity to decommission and store previous and current submarines around the order of £35 million.

Larger costs are associated with environmental and decommissioning costs at the nuclear sites supporting the fleet, along with the disposal of the fissile material from warheads and irradiated components. It should be recognised that much of this decommissioning liability has already been incurred and will need to be handled in the near term whatever decision is taken over future systems (see table below – these costs are not included in the calculations), and that the defence budget would be liable to further decommissioning spend over the following few decades, to clean up sites, decommission redundant equipment, and other activities on an on-going basis. Decommissioning activities typically take many years, sometimes several decades, and this timescale is also taken into account in estimating these costs.

Facilities and equipment requiring near-term decommissioning

Site	Description	Cost £m
Dounreay	Decontamination & decommissioning of test reactors	2533
T.B.C.	Research, development and construction of waste repository	1250
Springfields, Capenhurst and Sellafield	Storage of nuclear materials	1110
Rosyth & Devonport	Berthing & decommissioning of redundant submarines	599
Sellafield	Misc., largely storage of low-level waste	211
		Total: 5703

Source: Parliamentary Written Answer, Des Browne MP to Paul Flynn MP, 24 July 2006, Hansard, column 778W. [41]

Relocation of bases in Scotland

The referendum on Scottish independence on 18th September has been throwing up questions around the cost of relocation were a new Scottish government to insist on the removal of nuclear weapons from its territory. There would be several options to negotiate upon, but in the event of such a negotiation essentially officials would be considering either relocating the bases or seeking to treat them as foreign bases in Scotland. Both options have financial and political implications. Then Armed Forces Minister Nick Harvey said in evidence to the Scottish Affairs Committee in June 2012 that the costs would run to a great deal more than the £3.5 billion recently spent upgrading Faslane for the Vanguard and Astute class submarines; he claimed that 'that figure would be dwarfed'.[42] It would not only be the financial costs that would cause a headache: local opposition to siting the facilities in England or Wales is likely to be substantial, and safety issues around new storage of the warheads and the facilities to load and unload them from submarines could also add considerably to the expense. Given the political sensitivity in Scotland of allowing its neighbour to continue to use the facilities for the storage and deployment of nuclear weapons, the new Scottish government would look for substantial compensation from the rest of the UK to allow the full sovereign use of the bases, even if temporarily. The result of the referendum will be known in three month's time. But even a narrow 'No' vote would still call into question the long term viability of major investments that committed to siting facilities within Scotland. This would have to be included as a substantial project risk in the longer-term investment planning for the Ministry of Defence.

Conclusion

There are a number of estimates of the overall cost of going forward to maintain continuous at sea deterrence through a ballistic missile submarine force, but the numbers involved are often difficult to attach meaning to. We have chosen here to focus on the equivalent annual cost today, derived from the New Present Value of future spend. To continue the current system and construct four replacement SSBNs over the period 2016 to 2062, the equivalent annual cost today is £2.9 billion, or 9% of the defence budget, though in the coming years the actual annual cost will be a great deal higher than this (reaching a peak of £4 billion a year in the mid-2020s). There are a number of assumptions attached to this figure, and it could just as easily increase as unforeseen circumstances occur. If there were a forced decision taken to relocate the bases from which the submarines patrol and the warheads stored and loaded, the costs would be dramatically more. Many may judge a nuclear deterrent of such capability worth the cost, but in these times of high pressure on public finances and the defence budget in particular, it would be irresponsible to automatically assume it. Over the next two decades the defence budget faces a very tough squeeze caused largely by a contraction in defence spending that looks long term in nature, coinciding with a procurement bulge forecast to build up over the next decade and coinciding with the peak spending on the Trident renewal project. Decision-makers will face difficult choices between defence capabilities.

Endnotes for Paper 3

1 Paul Ingram is the Executive Director of the British American Security Information Council (BASIC), and led the secretariat servicing the Trident Commission 2011-14. This paper was largely written in 2012 for the exclusive use of the Commission, and has been updated for publication.

2 All figures in this report use 2012 prices unless otherwise stated.

3 www.guardian.co.uk/uk/2006/sep/21/military.armstrade

4 'In the Firing Line', Greenpeace, 2009, http://www.greenpeace.org.uk/files/pdfs/peace/ITFL_trident_report.pdf
Richard Norton-Taylor, 'New Trident system may cost £76bn, figures show', The Guardian, 21 September 2006, http://www.theguardian.com/uk/2006/sep/21/military.armstrade

5 Keith Hartley, 'Defence Industrial Issues: Employment, Skills, Technology and Regional Impacts', Second report for the BASIC Trident Commission. His estimate was £87.4 billion in 2011 prices.

6 Paul Dunne, Samuel Perlo-Freeman and Paul Ingram, 'The real cost behind Trident replacement and the carriers', October 2007, http://www.basicint.org/sites/default/files/cost.pdf.

7 Steve Schifferes, UK economy 'faces decade of pain', BBC News, 23 April 2009, http://news.bbc.co.uk/1/hi/business/8015063.stm

8 See official HMT Pocket Databank latest release (4 June 2014), tables 11a and 11b, available on the HM Treasury website: http://www.hm-treasury.gov.uk/data_indic_index.htm . Also Public Sector Finances March 2014, HMT, March 2014.

9 Public Sector Finances March 2014, HM Treasury, March 2014

10 Hansard, 4 December 2006, Column 23.

11 See, for example, Lords Boyce and Bramall contributions to the debate in House of Lords, 22 November 2007, Hansard Columns 950 and 956.

12 Defence Reform: An Independent Report into the Structure and Management of the Ministry of Defence (London: The Stationery Office, June 2011).

13 'Securing Britain in an Age of Uncertainty: The Strategic Defence and Security Review', Cm 7948, October 2010 Forward, p. 3. http://www.direct.gov.uk/prod_consum_dg/groups/dg_digitalassets/@dg/@en/documents/digitalasset/dg_191634.pdf

14 *Ibid,* p. 3.

15 Malcolm Chalmers, 'Looking into the Black Hole: Is the UK Defence Budget Crisis Really Over'? *RUSI Briefing Paper,* September 2011, summary.

16 'Britain fixes defence budget "black hole" – reports', Reuters, 13 May 2012. http://uk.reuters.com/article/2012/05/13/uk-britain-fixes-defence-budget-black-ho-idUKBRE84C06E20120513

17 Malcolm Chalmers, 'Respite from the Storm? Defence and the 2013 Spending Review outcome', *RUSI Analysis,* 28 June 2013, https://www.rusi.org/go.php?structureID=commentary&ref=C51CD74A8B34FD#.U5hiYa1dVy8

18 Malcolm Chalmers, 'Looking into the Black Hole: Is the UK Defence Budget Crisis Really Over?' *RUSI Briefing Paper,* September 2011.

19 Malcolm Chalmers, 'Is the UK Defence Budget Crisis Really Over?', *RUSI Briefing Paper,* September 2011, p.11, https://www.rusi.org/downloads/assets/RUSIBriefingPaperSept2011.pdf

20 See, for example, Toby Fenwick, 'Dropping the Bomb: a Post Trident Future', Centre Forum, 2012. http://centreforum.org/assets/pubs/dropping-the-bomb.pdf. Fenwick's principal thesis is that the UK faces a simple choice between investing in the next generation of nuclear ballistic missile submarines or sufficient conventional capabilities to deliver on the Government's ambitions for the UK as outlined in the Strategic Defence and Security Review. His contention, supported by a number of other analysts, is that the SDSR has failed to properly stick within the resources available. Fenwick identified a shopping list of alternative equipment spend that would dramatically improve the armed forces capabilities to project power globally.

21 Figures are taken from the National Audit Office, Major Projects Report 2013, HC 817, 13 February 2014, figure 12, p.40.

22 The nearest public equivalent today is the DEL minus depreciation, which in 2010-11, the latest figures available, was £28.0 billion. Public Expenditure Statistical Analysis, Departmental Budgets, HM Treasury, table 1.3a, available: http://www.hm-treasury.gov.uk/d/pesa_2011_chapter1.pdf

23 House of Commons, Official Report, 30 October 2007, Column 1358W.

24 The cost of conventional forces supporting Vanguard was not included in the government's initial estimates, Parliamentary answer from Bob Ainsworth to Nick Harvey, Hansard, 8 June 2009, Column 698W, http://www.publications.parliament.uk/pa/cm200809/cmhansrd/cm090608/text/90608w0004.htm

25 Parliamentary answer from Des Browne to Nick Harvey, Hansard, 8 March 2007, Column 2131W, http://www.publications.parliament.uk/pa/cm200607/cmhansrd/cm070308/text/70308w0007.htm Figures were given as £25-30 million and £250-300 million respectively, in 2007 prices.

26 See Stephen Jones, 'Recent Developments at the Atomic Weapons Establishment', House of Commons Library, Standard Note SN/IA/05024, 24 March 2009.

27 Figures based upon a House of Commons written answer from Peter Luff to a question from Caroline Lucas, given 19 June 2012, Commons Hansard, Column 932W. The original figures were given at outturn prices; these here have been transferred to 2012 figures using HMG's deflator.

28 Value for Money Review, note by the Ministry of Defence, available at: http://nuclearinfo.org/files/Trident%20VFM%20Review_0.pdf

29 'The United Kingdom's future nuclear deterrent: the submarine', Initial Gate Parliamentary Report, May 2011, p.5, http://www.mod.uk/nr/rdonlyres/7f9f5815-c67b-47b1-b5c4-168e8ab50dc3/0/submarine_initial_gate.pdf

30 Keith Hartley, 'The Economics of UK nuclear weapons policy', *International Affairs,* Vol 82, Number 4 (2006) pp. 675-676.

31 National Audit Office, Ministry of Defence: The Major Projects Report 2009, HC 85-1 (London: HMSO), 2009, p. 4.

32 Paul Dunne, Samuel Perlo-Freeman, Paul Ingram, 'The real cost behind Trident replacement and the carriers', 7 October 2007, available at http://www.basicint.org/sites/default/files/cost.pdf ; This uses the government's GDP deflators at market prices available on the HM Treasury website: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/205904/GDP_Deflators_User_Guide.pdf

33 Government Accountability Office report to Congressional Committees, Defence Acquisitions, Assessments of Selected Weapon Programs, March 2012. Available http://www.gao.gov/assets/590/589695.pdf Figures are in FY2012 dollars and use a 19 June 2012 exchange rate for the sterling figures.

34 Ronald O'Rourke, Navy Ohio Replacement (SSBN[X]) Ballistic Missile Submarine Program: Background and Issues for Congress, Congressional Research Service, 12 June 2012, http://www.fas.org/sgp/crs/weapons/R41129.pdf

35 'The United Kingdom's future nuclear deterrent: the submarine', Initial Gate Parliamentary Report, May 2011, p.8 http://www.mod.uk/nr/rdonlyres/7f9f5815-c67b-47b1-b5c4-168e8ab50dc3/0/submarine_initial_gate.pdf

36 SDSR 2010, paragraph 3.12, p. 39.

37 Note from Rear Admiral Simon Lister on Nuclear Submarines Infrastructure – Scope to Minimise Future Costs paper DES-SM LoD-Infra-01/03, dated 7 July 2010 and available here: http://nuclearinfo.org/files/Trident%20VFM%20Review_0.pdf

38 Philip Hammond's announcement to the House of Commons, 6 March 2014. See also letter dated 10 April to James Arbuthnot MP, Chair of the Commons Defence Committee, available here: http://www.parliament.uk/documents/commonscommittees/defence/140410-Hammond-MOD-HMS-Vanguard-refuelling.pdf

39 See annex 1 for an explanation of the net present value and equivalent annual cost.

40 There have been various estimates for the cost of this work. The cost of this process for all past and current UK submarines was estimated at some £1.75 billion in 2006. HCP 59, 2006, Government Response to Defence Committee, TSO, London, estimated £1.75 billion in 2006. Two years later, the government estimated current liability for in-service submarines (Vanguard and Trafalgar class fleets and HMS Astute) was only £265 million; see Answer from Bob Ainsworth to Alex Salmond, 4 February 2008, Hansard, column 801W. The answer gave £240 million, discounted in 2008 prices http://www.publications.parliament.uk/pa/cm200708/cmhansrd/cm080204/text/80204w0013.htm#column_801W. This report uses figures from the Parliamentary answer given in July 2006 by Defence Secretary Des Browne to Paul Flynn available here: http://www.publications.parliament.uk/pa/cm200506/cmhansrd/vo060724/text/60724w0015.htm

41 Answer from Des Browne to Paul Flynn, 24 July 2006, Hansard, column 778W, http://www.publications.parliament.uk/pa/cm200506/cmhansrd/vo060724/text/60724w0015.htm. 2005 prices were updated to 2012 level by using HM Treasury's latest GDP deflators.

42 'The Referendum on Separation for Scotland: Terminating Trident-Days or Decades?', Scottish Affairs Committee Fourth Report, October 2012, paragraph 38, http://www.publications.parliament.uk/pa/cm201213/cmselect/cmscotaf/676/67607.htm

Paper 4
Later steps down the nuclear ladder: threshold status

Ian Davis[1]

What is threshold status?

Threshold status can be defined as the ability of a state without deployed nuclear weapons to produce them within a matter of months or years, using such fissile material at their disposal and associated technological skills and materials available to it, and to deliver them using a credible system – be that using missiles, aircraft or boats. Generally it is a term that refers to states yet to develop nuclear weapons, including Argentina, Brazil, Canada, Germany, Japan, Sweden and Switzerland.

Today Sweden denies any military nuclear ambitions, but its past work in this field and technological capabilities give it the capacity to develop and deploy nuclear weapons on a tight timescale should its intentions change.[2] In contrast, whilst South Africa actually possessed a small nuclear arsenal in the 1980s, the country rapidly moved through threshold status and now no longer retains a capability. It is the world's first and only de facto nuclear weapon state to have unilaterally and voluntarily dismantled its indigenous nuclear-weapons programme, including its knowledge and experience base, and to have subsequently joined the NPT as a Non-Nuclear Weapon State (NNWS). Although undertaken initially without any international verification, it is believed that the programme was completely dismantled, including the destruction of all hardware design, manufacturing and other sensitive data. South Africa's weapons-grade uranium (with a very high concentration of U-235) was placed under IAEA safeguards. Clearly, South Africa could have retained a robust virtual capability had it wanted to, but chose not to do so.[3]

Threshold status stems from an old problem of the growing availability of weapon-usable nuclear materials through civilian nuclear programmes or dismantled weapons. The quantities of weapons-usable materials needed to make a nuclear weapon depend on the technical sophistication and desired yield of the device, but a complex design uses as little as 15kg of uranium-235 or 4kg of plutonium-239.[4] The UK alone has over 21,000kg of highly enriched uranium (just under 1,400,000kg globally), 3,500kg of military plutonium (230,000kg globally) and 91,000kg of civilian plutonium (260,000kg globally).[5]

Possession of these materials could enable a technologically-advanced NNWS to assemble and deploy nuclear weapons, measured by reference to its physical stockpile, infrastructure and fuel-cycle status; and the knowledge and experience needed to design, assemble and deploy the arsenal. Japan, for example, is widely thought to have a high latent ability to produce nuclear weapons on the basis of materials, technology and knowledge, even though the country has no experience in weapon design and production. Opinion is divided as to how quickly Tokyo could build a bomb: some suggest that its sophisticated electronics sector and large fuel cycle facilities would enable it to do so in a matter of weeks and months, while others argue in terms of several years.[6]

With sufficient fissile material available, weapons can be designed and engineered outside of dedicated research facilities, such as within university physics departments. Similarly, most weapon components could be fabricated in manufacturing facilities developed for a wide range of civilian purposes. Indeed, a threshold state may decide to invest in particular dual-use technologies with the clandestine purpose of improving their 'break-out' capabilities (developing future strategic options). A key question with all of these threshold or latent nuclear powers, therefore, is not whether they could build nuclear weapons, but rather how quickly they could build them and what sort of conditions would enable them to do so. Few, if any, have rapid 'break-out' status.

Rapid breakout refers to the possibility of assembling a nuclear weapon relatively quickly (measured in months rather than years), but often initially with minimal attention to safety, surety and delivery systems. India, Pakistan and North Korea all emerged as de-facto nuclear weapon states after going through a 'break-out' phase. International opinion is divided as to whether Iran is also now moving from nuclear latency to a break-out capability. But even a threshold status without such a break-out capability may be seen as valuable by a number of states facing uncertain security futures.

Stepping down the nuclear ladder

For a current nuclear weapon state, threshold status involves maintaining a long-term minimum capacity to reconstitute an arsenal whilst strengthening the credibility of its non-proliferation agenda and saving money in the near term. No recognised nuclear weapon state with a significant arsenal has yet chosen this option.

Threshold status in the context of deconstructed nuclear weapons was first conceptualised in 1984 by the influential nuclear theorist, Jonathan Schell, and later revised in a multilateral context by Michael Mazarr, professor of strategy at the US National War College.[7] Schell described a world in which nuclear weapons were dismantled but where some states possessed a defined capability to rearm within weeks or months. Writing in the 1990s, Mazarr argued in favour of virtual nuclear arsenals as a means of: eliminating the risk of nuclear accident or misuse; reducing the overall risk of nuclear use in a time of crisis by creating space for a cooling-off period; controlling Russian nuclear forces and materials; and reinforcing the non-proliferation regime.

What would threshold status involve for the UK?

In a study of future requirements for the US nuclear weapons construction complex, John Immele and Richard Wagner conclude that, as the number of nuclear weapons in the world decreases, nuclear infrastructures will have a greater role than nuclear stockpiles in dissuading future threats, and talked of the possibility of such infrastructures operating as a form of recessed deterrent. They go on to say that neither the major powers nor current and potential proliferators can be secure at very low numbers without understanding and managing the roles of latency and infrastructure.[8] If, perhaps as part of a set of global moves towards nuclear zero, the UK were to consider a move from ‘minimum deterrence’ to a high-end threshold status that enabled it to rapidly reconstitute an arsenal in the future, it would need to continue to nurture its nuclear knowledge and experience in an effective stewardship programme for several decades. Any nuclear hedge against future acts of aggression would require reconstitution of capabilities in the build-up, and sufficient probability of survival of the nuclear infrastructure and know-how to threaten a second strike capability (albeit delayed). Some analysts have termed this ‘virtual nuclear deterrence’, though this term has been controversial amongst Trident Commissioners because some believe it sits so far from our current conception of deterrence as to stretch the meaning of the term, and they remain sceptical of its genuine efficacy in times of crisis.

Those supporting the possibility of a virtual nuclear deterrent would say that it is not the possession of a physical nuclear weapon on alert that is a prerequisite of nuclear deterrence; rather, they would say, it is the ability to deliver a nuclear weapon on an adversary now or in the future. US and Israeli strategic calculations over whether to attack Iran to degrade its nuclear capabilities are surely affected by Iran’s potential to rapidly reconstitute and accelerate development of its nuclear infrastructure afterwards. A former nuclear weapon state would be much further down the road, in terms of the knowledge possessed by nuclear weapons designers and technicians, and thus possess some form of deterrent, though at a far less salient level than what they have today.[9]

There is a continuum of threshold status postures. A country like the UK that would have possessed nuclear weapons and then retains the resources needed to produce them might be assumed to exercise a potent 'high-end' form. A country like Brazil, that is developing a civilian nuclear programme with uranium enrichment and is developing nuclear–powered submarines, could currently be said to possess a much less potent, 'low-end' threshold status.

In moving towards threshold status, the UK would want to straddle two competing objectives to meet international non-proliferation and arms control commitments and give credible assurances of a cost-effective and long-term hedge against future nuclear threats whilst there is the realistic possibility that they may re-emerge. One way of seeing this status is as a series of dynamic steps down the ladder that gradually lengthens the rearmament process as confidence in the threshold status grows. This would involve investment in a nuclear infrastructure and components that involve steadily reducing levels of readiness over the period of several decades as the international environment evolves.

The first steps might involve a shift to a non-deployed or non-operational nuclear arsenal. This might involve some combination of an end to continuous-at-sea deterrence (CASD), the de-mating of nuclear warheads from their missiles, the removal of fuel from the Trident II missiles and deactivation of guidance sets.[10] A small stockpile of Trident missiles would either be kept on board or stored at Coulport, and 20-40 disassembled warheads would be stored at the Atomic Weapons Establishment (AWE) at Aldermaston. These steps would build on earlier de-targeting and ‘reduced notice to fire’ decisions taken by the British Government in 1995 (as well as by the other four NPT nuclear weapon states). De-targeting was achieved through modest computer and operational changes that could, as Sir Michael Quinlan noted, be reversed in a matter of minutes.[11]

Steps down the ladder

This table includes an *indicative* timeline were decisions taken to move in the direction of a virtual status. Decisions taken at different points in the procurement cycle may involve differences in the timeline.

Indicative timeline	Submarines	Missiles	Warheads
First decade	Drop CASD, retain irregular patrols. Freeze modernisation programme.	De-mate from warheads. Withdraw from active service.	De-mate from missiles & withdraw from active service. Begin design of new warhead for basic dual-use delivery system.
First & second decade	Drop patrols altogether, except for training.	Missiles stored whole in Coulport, not loaded.	Warheads stored whole in Aldermaston, not loaded.
Near end of second decade	Submarines mothballed.	Fuel removed, guidance deactivated. Missiles returned to US, but leasing rights retained.	Warheads: first, triggers & pits stored separately. Later, warheads fully dismantled & components stored separately.
Third decade	Subs dismantled, moved to planned alternative (dual-use) delivery system existing in UK.	Delivery system plans in place (eg, free-fall bomb or air or sea-launched cruise missiles) for development &/or manufacture.	Retain knowledge & plans at Aldermaston, with focus on capacity to produce, rather than stockpiling of materials.

One of the key factors is the speed of reconstituting a system if deemed necessary. Dedicated SSBN submarines take many years to construct and are extremely expensive, so other dual-use, cheaper options would be more attractive propositions. At least four credible options could be available (and are explored in more detail in the following chapter):

- A redeveloped gravity bomb similar to the modified US B61-12 or a stand-off nuclear-tipped cruise missile for delivery by the RAF on the new stealthy US F-35 or longer range strategic bomber.
- Horizontal-launched cruise missiles from the Astute-class attack submarines, assuming a new low-radiation warhead could be designed, or modification to the Astute submarines to carry vertical-launched cruise missiles.
- Horizontal-launched cruise missiles from dual-purpose diesel submarines (if the national capability to produce nuclear-powered submarines were to be lost). Israel's German-supplied diesel-electric Type 800 Dolphin-class submarines offer a potential model, with land-attack cruise missiles capable of carrying tactical nuclear warheads.
- Cruise or ballistic missiles launched from Destroyers.

The stockpiles of largely dismantled or non-operational nuclear weapons would be retained under national control, but could be subject to some form of yet-to-be-developed international verification process.[12] The disassembled component parts (missiles and warheads) would be placed in 'cold storage' with the option of being made ready within a matter of weeks or months, together with nuclear weapon physics packages that could be made ready in the same timeframe.[13]

This might therefore include the retention of:

- safeguarded weapons-grade fissile material (the UK has sufficient fissile material to support the current warhead stockpile and the requirements for submarine nuclear reactors for the next 75 years);
- some safeguarded components specific to nuclear weapons, including specialist chemical explosives, fuses, neutron initiators, tampers, etc.;
- documentation about former nuclear weapons programmes;
- relevant civilian nuclear laboratories and research reactors, and the general industrial capabilities required to produce nuclear weapons; and,
- trained personnel.

AWE at Aldermaston would have a key role in disassembling and reassembling nuclear warheads. In his 'emergency alert' scenario, Nick Ritchie envisages warhead reassembly being staggered so that a few weapons could be made available on short notice with full-scale redeployment measured in months.[14] He also proposes annual exercises to re-assemble actual or mock warheads for loading onto Trident missiles aboard SSBNs at Coulport and, if necessary, the capability to return to operational patrol, at least until the Vanguards were unavailable.

In any case, AWE's scientists would need to redevelop their weapons design skills, as well as work on national nuclear security, verification and confidence-building, to contribute to an international inspection regime. AWE could also expect its activities to face a high degree of scrutiny as other nations sought to verify that the UK had indeed decommissioned its nuclear weapons.

The weapons handling and storage facilities at Coulport could stockpile some of the disassembled missiles and warheads, as part of a de-mated missile stewardship programme. A UK-based missile stewardship programme would probably require a new series of agreements with US contractors, Lockheed Martin and General Dynamics Advanced Information Systems.

Faslane (submarine basing) and Devonport (submarine refit and maintenance) would continue to service the UK's nuclear attack or conventional submarines and warships. Overall, however, the shore infrastructure would probably not require any significant new investment (other than to 'harden' some of the facilities to increase their capacity to survive a precision conventional attack) and could anticipate some scaling back over time.

In the short term, the main financial benefits would derive from cancellation or freezing of procurement programmes and an end to continuous patrols. If the UK were to retain the option to design, build and operate nuclear attack submarines (including potentially utilising the boats as a recessed dual-use nuclear capable platform), it would be advantageous for the UK to continue a reshaped deep collaboration in submarine technology with the US Navy and US defence suppliers. This would mean re-negotiating the Mutual Defence Agreement as well as many of the other development commitments currently associated with a sea-launched ballistic missile capability to reflect the move to threshold status. It may be that an approach by the UK to change the basis of technical cooperation would attract disappointment and opposition in Washington, and put London on the back foot in negotiations with the Administration, harming the transatlantic relationship; but this should not be assumed, and any damage would in all likelihood be temporary.

Is it feasible and desirable?

The US experience with its vast 'inactive reserve' stockpile confirms that it is technically possible to store and manage the key components of disassembled warheads for long periods of time with processes in place for re-assembly and redeployment. The UK has the appropriate industrial infrastructure and expertise to adopt a threshold posture with a credible reverse gear. After all, on the way up the nuclear ladder, the UK took only 33 months to progress from the drawing-board to an air-dropped test device in 1957.

How quickly the UK could rebuild a nuclear weapon would depend on the status of the threshold capability, and a number of requirements such as surety and safety. In the early period, with disassembled warhead components at Faslane, and Trident missiles stored aboard the Vanguard submarines in port, this could be in a matter of days or weeks. Further down the curve, this could stretch to months or even years.[15] Threshold status would in effect be combined with and gradually replaced by other emerging forms of non-nuclear retaliatory capabilities.

There are four main risks arising from such a posture:

- the increased vulnerability from a first strike – any deterrent effect arising from the uncertain threat of a longer-term nuclear response from a state with threshold nuclear status would be far less salient than any state possessing a nuclear arsenal;
- the difficulty of retaining a credible threshold posture in the long run, so that an active stewardship programme would be required along with a recognition that this would not be sustainable and could only be an interim step towards full disarmament or the reconstitution of the arsenal;
- the destabilising nature of rearmament in a crisis, with the danger that we could end up in a rapid and unstable arms race to achieve an arsenal and a deterrent posture should a strategic crisis emerge, or a state tempted to use their temporary advantage before their adversary had a chance to reconstitute their nuclear arsenal; and
- potential diplomatic and strategic risks, with the possibility that abandoning an active nuclear arsenal could be seen as traitorous to alliance relationships or destabilising current balances, unless the move were made in concert with allies and other world powers.

A glide-path towards disarmament

A threshold posture might provide a degree of strategic flexibility with the possibility of both leaving the path (and returning to a fielded nuclear weapon system) were the strategic environment to darken, or accelerating down the path if the situation allows. More work would be needed on the conditions required to facilitate a temporary or long-term threshold posture before this option could be a globally-accepted route towards fulfilling the disarmament requirements of Article VI of the NPT, and on what the alternatives might be.

In order to provide some clarity, and given the potential for other NWS to follow a similar path, it would be useful for the UK to undertake some studies and consultations to help clarify matters, perhaps by building on existing verification work. The UK-Norway warhead dismantlement initiative could be adapted to study not only the practical steps necessary for transition from being a NWS with a 'minimum deterrent' to a virtual NWS (and eventually a NNWS), but also how this might be 'sold' to sceptics on both sides of the nuclear weapon divide. Such studies could be conducted in consultation with other NWS with a view to bringing them into the process.

Endnotes for Paper 4

1 Ian Davis is the Director of NATO Watch, and formerly Executive Director of BASIC (2001-07).

2 See Andreas Persbo, 'The Blue and Yellow Bomb', Part I, Arms Control Wonk, 16 November 2009, http://guests.armscontrolwonk.com/archive/2535/the-blue-and-yellow-bomb-part-1; and Thomas Jonter, 'The Swedish Plans to Acquire Nuclear Weapons, 1945–1968: An Analysis of the Technical Preparations', *Science & Global Security,* Vol. 18, 2010, pp. 61–86.

3 Belarus, Kazakhstan and Ukraine also decided to forego any virtual capabilities they inherited from the Soviet Union via diplomacy and transfers of weapons to Russia.

4 The International Panel on Fissile Materials, Global Fissile Material Report 2013: Increasing Transparency of Nuclear Warhead and Fissile Material Stocks as a Step toward Disarmament, (Appendix: Fissile Materials and Nuclear eapons), p. 92, http://fissilematerials.org/library/gfmr13.pdf

5 Estimates from the International Panel on Fissile Materials, fissile material stocks at January 2013. Source: http://fissilematerials.org/ These figures have been compiled from publicly-available sources by a network of scientists and academics.

6 For an analysis of these views and referral to more in-depth sources, see Jeffrey Lewis, 'How Long for Japan to Build a Deterrent?' Arms Control Wonk, 28 December 2006, http://lewis.armscontrolwonk.com/archive/1339/japans-nuclearstatus; NTI, 'Japan country profile', last updated January 2014, http://www.nti.org/country-profiles/japan/nuclear/ ; and, Emma Chanlett-Avery and Mary Beth Nikitin, 'Japan's Nuclear Future: Policy Debate, Prospects, and US Interests', Congressional Research Service,19 February 2009, (via the Federation of American Scientists, http://www.fas.org/sgp/crs/nuke/RL34487.pdf).

7 Jonathan Schell, *The Abolition,* New York, NY: Knopf Doubleday Publishing Group, 1984, pp. 118–120; Michael Mazarr, *Virtual nuclear arsenals: A second look,* Washington, D.C.: CSIS, 1999; Michael J. Mazarr, (ed.) *Nuclear weapons in a transformed world: The challenge of virtual nuclear arsenals.* New York, NY: St. Martin's Press, 1997; and Michael J. Mazarr, 'Virtual nuclear arsenals', *Survival*, Vol.37, No.3, 1995, pp. 7-26.

8 'The US Nuclear Weapon Infrastructure and a Stable Global Nuclear Weapons Regime', draft paper, John D. Immele and Richard L. Wagner, 19 January 2009 - posted on the Strategic Weapons in the 21st Century Conference website: http://www.lanl.gov/conferences/sw/2009

9 See, for example, 'The US Nuclear Weapon Infrastructure and a Stable Global Nuclear Weapons Regime', draft paper, John D. Immele and Richard L. Wagner, 19 January 2009.

10 Nick Ritchie, 'Stepping Down the Nuclear Ladder: Options for Trident on a Path to Zero', Bradford Disarmament Research Centre, May 2009, http://www.brad.ac.uk/acad/bdrc/nuclear/trident/Trident_Options.pdf

11 House of Commons Defence Committee, HC986-I, Memorandum submitted by Sir Michael Quinlan, 14 March 2006.

12 A 'dismantled warhead' usually means that the warhead's high explosives have been separated from its fissile material components.

13 The arrangement of nuclear materials, explosives and various other non-nuclear parts essential to the detonation of a nuclear warhead are generally and collectively referred to as a device's 'physics package'.

14 Nick Ritchie, 'Stepping Down the Nuclear Ladder: Options for Trident on a Path to Zero', Bradford Disarmament Research Centre, May 2009, p. 8, http://www.brad.ac.uk/acad/bdrc/nuclear/trident/Trident_Options.pdf

15 Toby Fenwick, 'Dropping the bomb: a post Trident future', Centre Forum, 2012, http://www.centreforum.org/assets/pubs/dropping-the-bomb.pdf

Paper 5
Alternative delivery systems and their platforms

Matt Cavanagh[1]

Options

If the United Kingdom is to continue to actively deploy nuclear forces, is a like-for-like renewal of the current system based on dedicated, continuously patrolling Trident SSBNs (ballistic missile submarines) the best – or as some argue, the only practicable – option? The Commission considered this question in the light of the 2006 White Paper, this supporting brief, and the Trident Alternatives Review.

The 2006 White Paper gave a short overview of some of the options considered by the government at that point, before committing to a like-for-like renewal. That exercise was premised on a strong assumption that any alternative system would need to provide a similar deterrent capability to the existing system. More recently, the current Government published its Trident Alternatives Review on 16 July 2013, as part of the Coalition agreement that maintained the plans set out in the 2006 White Paper while at the same time (at the behest of the Liberal Democrats) examining 'whether other postures or weapons systems might deliver a credible alternative nuclear deterrent'.[2] The Alternatives Review departed from the approach of the 2006 White Paper by relaxing the formal requirement that any new system have a similar capability to Continuous At Sea Deterrence (CASD), instead weighing up the options on the basis of a number of criteria, including range, survivability, and destructive power. The Commission considered a variety of alternatives to the current plans, with no fixed assumptions.

This background paper looks at a wide range of possible UK choices of nuclear weapon systems, each of which is made up of three basic components:

- the warhead, which generates the nuclear explosion;
- the delivery system, the missile or bomb which delivers the warhead to the target: this includes ballistic missiles, cruise missiles, and free-fall bombs; and
- the platform from which the missile or bomb is launched: this includes submarines, ships, aircraft, land-based silos, and land-based mobile launchers.

The different components of platform and delivery system are worth separating, even though there are a number of inter-dependencies between them. The choice of platform influences and constrains the choice of delivery method, and vice versa.

This support brief was largely written before the Trident Alternatives Review report was published, and has an approach that is different and complementary to it. Crucially, this brief does not involve recommendations, nor any attempt to provide detailed costings of the options – rather it aims to set out the positive and negative features of each option in general terms (including very broad estimates of cost).

It is worth noting at the outset how far the UK's historic preference for a submarine-based ballistic missile system, which dates back to the 1960s, is based on two criteria above all: first, it is invulnerable to pre-emptive attack even by an adversary with military capabilities as sophisticated as the Soviet Union in that era; and second, it met the so-called 'Moscow criterion', of guaranteeing to defeat anti-missile defences as sophisticated as those around the Soviet Union's capital.

These two criteria were believed to be necessary conditions for the system functioning as a credible deterrent against either nuclear attack or overwhelming conventional attack from the Soviet Union – which was then deemed to be the major strategic threat to the UK. Since the end of the Cold War, these are no longer the formal criteria, but they appear to continue to exercise a hold on British thinking, on the basis that if a weapon system is credible against such an adversary, it is credible against all others too.

There is still a tendency in much of the UK debate, including inside the UK government, to present each of these as a non-negotiable requirement of any future system. While it would be unfair to describe this as 'rigging' the outcome, it radically cuts down the feasible options. A requirement of virtual invulnerability to pre-emptive strike from the most sophisticated potential adversary almost entails a system based on submarines on continuous patrol; and a requirement to guaranteeing to defeat the most sophisticated defences strongly favours a system based on ballistic missiles able to deliver a large number of warheads on a given target in a short space of time.

A proper debate should not rely unquestioningly on the same two assumptions, but should look at all the options on their merits, and consider the trade-offs they involve, including between invulnerability, capability, and cost.

Ballistic missile options

Advantages of ballistic missiles

Ballistic missiles have long been seen as the 'gold standard' for delivering nuclear warheads, because of their range, accuracy, speed of delivery, and the difficulty of interception. Modern ballistic missiles, including the Trident missile, can launch multiple independently targeted warheads (in the case of Trident, up to 14 for each missile) once the missile re-entry vehicle enters the Earth's atmosphere, enabling attacks on a scale that would have a high probability of overwhelming any defences.

Britain does not itself have an existing production capability for ballistic missiles, and it would be extraordinarily expensive to set one up. The recent French programme for a new ballistic missile and warhead (to be launched from submarines) is estimated to cost €16 billion (£13 billion).[3] Even upgrades and life extensions of existing ballistic missile systems run into many billions of dollars.[4] In the British case, the design and production of ballistic missiles would have to be started without an existing industrial base.

So the practicality and affordability of ballistic missile options depends upon any proposed system being capable of using the Trident missiles in the pool shared with the United States, and their willingness to continue to support any such arrangement, or if the UK could negotiate a similar purchase or lease arrangement using an alternative missile.

There is another specific advantage to ballistic missile options, which is highlighted in the Trident Alternatives Review. The UK already has its Trident warhead. Any alternative delivery system would require the development of a new warhead, something that would take significant time and money. A UK programme to develop a new warhead would likely have some dependencies on the United States, and the variable of US warhead developments (currently unclear) has to be taken into account when making such estimates. The Trident Alternatives Review suggested that a new warhead would take 17 years to design and produce, and an extra seven years on top of this if designed for a new delivery system. The Alternatives Review rests very heavily on these estimates,[5] which there is no easy way to verify – though they appear to be conservative.

Cheaper options involving ballistic missiles from submarines

A system based on ballistic missiles launched from submarines gives the UK the capability to launch an attack of global range and devastating scale, from a covert location which is invulnerable to pre-emptive attack. The submarine can be many thousands of miles away from its target in any direction, and is virtually undetectable until it fires a missile. At that point it becomes somewhat more vulnerable, but even the first missile can achieve the necessary scale, in virtue of carrying multiple independently targeted warheads.

Can significant savings be made on current plans, while preserving the basic features of this system? The major procurement cost is the acquisition of a new fleet of three or four SSBNs, estimated by the government in the range £11-14 billion in 2006 prices (or £25 billion at out-turn prices).[6] A number of options have been floated for reducing this cost.

The most radical is to adapt the design of the Astute-class attack submarine, to produce a version able to launch Trident missiles. The UK has committed to building seven Astute-class submarines,[7] of which three have been completed. The remainder are planned to enter service over the next ten years. They have a design service life of 25 years (though with life extension this could turn out to be longer), and are powered by the latest version of the PWR2 reactor, 'Core H', which eliminates the need for refuelling, and which is also powering the Vanguard-class submarines after their mid-life refits. The last (seventh) Astute submarine will use the PWR3, the reactor slated for use in the Successor submarine.

The Astute-class is larger than previous attack submarines (in part to accommodate the PWR2), but Trident missiles, at 13.4 metres long, are significantly longer than the current diameter of the Astute's hull (its beam is 11.3m). The only realistic option would be to incorporate four Trident tubes into an extended "sail" (or fin) of the submarine. This would represent a reduction in missile tubes compared to current plans: the planned Common Missile Compartment for the SSBNs, being developed in cooperation with the United States, has eight tubes.

Astute-class submarines currently cost around £1.2 billion each to build. The question is whether building four additional adapted Astutes – or, if we are also prepared to drop the requirement of CASD (that is, drop the requirement that the deterrent force is able to guarantee continuous patrolling throughout the lifetime of the system), three or even two additional adapted Astutes – together with the additional costs of adaptation, would cost significantly less than the £11-14 billion estimated for the current plan based on an entirely new, purpose-built design.

Another radical option would be to build an additional four (or, if we are prepared to drop the requirement of CASD, three or even two) submarines to the old Vanguard-class design, using the PWR2 Core H reactor. However, while the design and the living examples still exist, the production line has long since been adapted to the new Astute-class, and the operational knowledge is receding into the past: the last Vanguard-class submarine was launched 14 years ago. Regenerating the capacity to build Vanguard-class submarines is likely to be more complex, and expensive, than adapting the Astute-class.

Finally, the least radical option is to stick with the current plan for a new generation of SSBNs, but drop the requirement of CASD and to build only three or two submarines. Both the previous and current administrations have committed themselves to building three rather than four if it were possible to maintain CASD.

Last year's Trident Alternatives Review states that with the current level of technology and procedures, it would be highly unlikely that the Royal Navy could deliver a high confidence CASD posture with only three submarines.[8]

Dropping the requirement of CASD could also allow a significant extension of the life of the current deterrent submarines, and thereby delay the need for a decision on the long term future of the UK's deterrent. The current deterrent submarines are planned to go out of service in the mid-to-late 2020s. If CASD is dropped immediately, this would allow the boats to be used less intensively for the remainder of their service life, potentially extending their life by several years, and increasing the chances that two or even three could remain operational past 2030.

Those sceptical of the potential for significant life extension – including the UK government – reply that while the service life of some elements of the current submarines is determined by usage, the service life of other elements is determined simply by time elapsed. This applies in particular to the reactor. The service life of the submarines is measured from the time the reactors went 'critical' (often a year or more before they became fully operational).

Ending CASD may, however, enable a solution to this constraint – and a more radical option for delay. Two submarines could be mothballed immediately, with their reactors shut down and removed. This would leave two submarines in service: not sufficient to maintain CASD, but arguably enough for a 'minimum credible' capability appropriate to the current security environment. As these two active submarines approached the end of their service life in the mid-2020s,[9] the two mothballed submarines could have their reactors re-installed and restarted; they would then have another fifteen or so years of service life. This would allow the UK to maintain two of the current deterrent submarines in service from now until the mid to late 2030s or beyond; thereby allowing a decision on the long term future of the UK system to be delayed until after 2020.

Delaying the decision until after 2020 would bring a number of advantages. First, it would push the decision-point and any resulting spending beyond the most severe period of the UK's current fiscal challenge. Second, it could widen the set of available options: for example, new cruise missiles could become available offering greater capability and range.[10] Third, the delay could see greater clarity on either or both multilateral disarmament, or geopolitical developments, which could have a bearing on the overall decision.

Clearly there is a great deal of risk and uncertainty surrounding this option. An unforeseen problem could lead to one of the in-service submarines being taken out of service, either temporarily or permanently. Even without the requirement of CASD, being left with only one operating submarine would be unacceptable. Another risk is that, when the time came to re-start the reactors on the mothballed submarines, technical problems would emerge that rendered them ineffective or unsafe. This would then leave the UK in a position where it had no nuclear weapons, with a gap of at least a decade before it could build replacement submarines or implement some other option.[11]

However, it should be noted that all decisions in this area essentially involve an estimate of risks and costs: it is possible to take a different view of the risks and costs to the one the UK government has hitherto taken; or to take a different view of how much risk, or cost, the UK should tolerate in exchange for more flexibility about the decision timetable.

Strengths and weaknesses

Maintaining a submarine-based ballistic missile system retains all the capability advantages of the current system: range, accuracy, difficulty of interception, and so on – assuming there are no game-changing developments affecting the detectability of submarines during the long lifetime of the system.

An Astute-based system, particularly one that involved dropping CASD and building two or three adapted Astutes, would likely cost significantly less than the £11-14 billion procurement cost estimated for the current plan.

The apparent cost advantages would have to be considered in the round alongside the implications for the UK's submarine industry. With the construction of additional, adapted Astutes, it would seem that a steady, albeit slower, production drum-beat could be maintained.

An Astute-based system would however have a significantly reduced capability due to the reduction in missile tubes (compared to current plans) from eight to four; but it should be noted that four missiles still generates a capability in excess of the current policy of a maximum 40 warheads on each submarine.

An Astute-based system would also not have the level of stealth envisaged for the new purpose-built SSBNs, though it should be noted that the Ministry of Defence has previously described the Astute-class as having 'unprecedented' stealth characteristics.[12]

More broadly, adapting the Astute-class illustrates the generic advantages and disadvantages shared by some of the options that will be discussed in the remainder of this chapter: any option which involves adapting existing designs or platforms, all other things being equal, reduces costs and increases flexibility, but this necessarily comes at the expense of various specific advantages of a tailor-made system.[13]

Ballistic missiles from land-based silos (ICBMs)

Land-based ballistic missiles have never been used in the UK, but it is a common system among other states with nuclear weapons. For reasons set out in 5.2.1 above, this option would only be feasible if the Trident D5 could be adapted to be launched from land-based silos, or if a similar arrangement could be negotiated with the Americans over purchasing or pooling their silo-based Minuteman III or similar missiles, as currently applies to the Trident II D5 missile.

Strengths

Like any ballistic missile system, this option has the advantages of long range, and high accuracy, together with very high speed, making it relatively difficult to intercept.[14] It would be less escalatory in a crisis than some alternatives (for example, aircraft-based systems), but more so than any submarine-based system, as in all likelihood it would require a launch-on-warning posture.[15]

Weaknesses

Silo-based systems are inherently less complex than submarine-based systems – and therefore cheaper all other things equal; however in the UK's case that generic advantage is likely to be more than off-set by the one-off costs in switching from a submarine system to a silo-based system which would have to be constructed from scratch (including, for example, a new hardened command and control system). In addition, even assuming that it would be possible to use an adapted version of Trident missiles, the adaptation process would incur significant costs. The 2006 White Paper talked of 'the likely need for an extensive engineering and test programme', the cost of which is likely to run into hundreds of millions of pounds.[16] The White Paper concluded that the overall costs of switching to a new silo-based system would be around twice the cost of current plans.

The principal generic weakness of silo-based systems is that the missiles are fixed in location, and therefore vulnerable to a pre-emptive first strike. Silos are impossible to conceal, and while they can be hardened to an extent, they would remain vulnerable to a well-targeted strike, especially by nuclear weapons. This creates incentive to have a launch-on-warning posture, which increases running costs and has escalatory implications.

Another weakness specific to the UK is that it may be hard to identify sites for the silos which would be sufficiently spread out to avoid an easy pre-emptive strike. Potential sites would also come up against severe local and political opposition.

Overall, combining the vulnerability, the very great difficulty of finding a site which is large enough and politically, as well as geologically, acceptable, and with great uncertainty over whether there would be any cost advantage, a silo-based system does not look like an attractive option.

Ballistic missiles from mobile land-based launchers

Like the previous option, whilst this has never been operated by the UK it is relatively common among other states with nuclear weapons. The cost position of such a system is similar to that discussed above in relation to silo-based ballistic missiles: generally cheaper than submarine options, but with one-off costs associated with switching to a new system.

Strengths

This option shares the advantages common to all ballistic missile systems (outlined above). Mobility in theory addresses the weakness of the other land-based system, a silo-based system, in terms of vulnerability to pre-emptive strike, if the launcher and missile can be deployed to secret locations. If concealment is successful, such a system would also be less escalatory than other systems where increases in readiness and activity would be more easily observable (but see below).

Weaknesses

As with a silo-based system, even assuming that it would be possible to use an adapted version of Trident missiles, the adaptation process would incur significant costs – likely to be even more expensive than a silo-based system.
It would require not just the mobile launchers, but new supporting infrastructure, and a new command and control system.

It is certainly possible that a minimally-credible system based on around 20-30 mobile launchers, using adapted Trident missiles, and a command and control system which was less hardened than the current system, would be cheaper than building a new generation of submarines, but there is a great deal of uncertainty over this.

While in theory mobile launchers are less vulnerable than silos to pre-emptive attack, concealment of launchers large enough to launch ballistic missiles is considerably harder than concealment of submarines.

The UK is small and relatively densely populated, making concealment of mobile launchers particularly difficult. The closest British experience to these considerations was when hosting US cruise missiles using mobile launchers based at Greenham Common and Molesworth in the 1980s, an experience that demonstrated the limitations of the system, as well as the potential for political controversy to surround and interfere with deployments.

The 2006 White Paper decisively rejected mobile land-based systems, based on 'serious concerns at the technological risks involved with developing such systems, given that no such capability is currently readily available from reliable sources'. It also cited 'major vulnerability and security difficulties in operating any such system within a relatively small and densely populated island'. Nevertheless, the fact that such systems are in wide usage, not just by states whose technology is more primitive, suggests that it should not be entirely dismissed.

Ballistic missiles from surface ships

Assuming that ships carrying the missiles would be dual-use (the most obvious candidate being the Type 45 destroyer), the cost of such a system is likely to be significantly cheaper than land-based ballistic missile systems, or new dedicated SSBNs. Though Trident missiles are far larger than missiles currently allocated to Type 45s (13.4 metres long compared to 4.2m for the Sea Viper missile), it would be possible, if challenging, to design a missile launch compartment. It would, however, be far easier to adapt Type 45s to fire nuclear cruise missiles – around 5m in length (this option is discussed later).

Strengths

As with other ballistic missile systems, this would only be feasible for the UK if Trident missiles could be adapted. As with adapting Trident missiles to launch from land-based silos or mobile launchers, adapting them to launch from a Type 45 would incur significant costs – likely to be in the hundreds of millions – but far cheaper than developing a new missile. Adapting a Type 45 should also be far cheaper than constructing a new platform or system.

The 2006 White Paper examined an option of ballistic missiles launched from surface ships, but it assumed the construction of three new purpose-built ships operating a CASD posture, additional Royal Fleet Auxiliary ships, destroyers or frigates, and one additional Astute submarine, to support and protect the nuclear-armed ships. Based on these assumptions, it assessed this option as being 'at least as expensive' as current plans. Dropping the requirement of CASD would allow the weapons to be based on two or three existing Type 45 destroyers (out of the UK's fleet of six) adapted for the purpose in parallel with other (conventional) tasks, using existing or slightly re-enforced protection. Dual-use would bring greater flexibility and cost-effectiveness. In an era when military platforms are growing increasingly expensive, thereby limiting the number even a country with relatively high defence spending can afford, employing dual-use platforms is generally a good strategy. It could also offer an opportunity to move 'down the nuclear ladder' without exiting it entirely. Continuous patrols could still be maintained during periods of high tension.

A variant on this version (similar to the option of adapting Astutes discussed above) would involve strengthening the Type 45 fleet with one or more additional ships, manufactured to the same design. This would cost somewhere just under £1 billion for each additional Type 45 (based on the cost of existing Type 45s). A cheaper option would be to convert two or three of the existing six Type 45s, and compensate for any loss of flexibility for conventional tasks by procuring additional Type 26 'Global Combat Ships', currently costed at £250-£350 million each.

The total cost of adapting the Trident missiles and the Type 45s would be relatively modest compared to the cost of building a new generation of ballistic missile submarines, perhaps no more than £2 billion. The additional costs of the necessary modifications to facilities at Faslane/Portsmouth were described in the 2006 White Paper as 'minor'.

This option has a high degree of flexibility associated with it, with adapted Type 45s able to fulfil both conventional and nuclear roles.

It also brings strategic flexibility, because the timelines are shorter than for many other options: adapting an existing missile and existing ships should be relatively quick. This option could be adopted as a 'fallback' solution, allowing scope for strategic delay in the final decision on the way forward for the UK's nuclear weapon system. The Type 45s are currently planned to remain in service until the mid-2030s, but extending the life of surface ships is much less problematic than submarines, and is done routinely.

For example, the decision on the long term future of the UK's nuclear weapon system could be delayed until after 2020. If at that point the security and disarmament landscape still justifies maintaining nuclear weapons, and if no better option has materialised, two or three Type 45s could be converted and could conceivably remain in service until the late 2040s (similar to the current plans for a new generation of SSBNs).

Weaknesses

Ships are fundamentally easier to track and attack and therefore more vulnerable than submarines to pre-emptive strike, though this can be overstated. When considered in its conventional role, the Royal Navy claims that the Type 45 has world-leading defences against aircraft and cruise missiles. There is some concern about its defences against submarines, though presumably they must be deemed adequate (and if not, then they should be upgraded).

The main vulnerability is to a pre-emptive attack, including by long-range ballistic missiles, particularly if the ship is in port. But it should be noted that this is a vulnerability shared by a submarine-based system not operating CASD. Once on patrol, long-range ballistic missiles are less of a threat to a Type 45 than to a fixed target like a silo-based weapon system: even in the short time taken by a ballistic missile flight, the Type 45 will have moved on an unpredictable course, and ballistic missiles cannot receive updated target information in flight.

If Type 45s were operating both nuclear and conventional roles, this would be demanding in the training required for crews; though it should be noted that several nations have operated dual-use platforms (including the UK relatively recently).

Given the advantages of a system based on Type 45s, the questions around vulnerability are worth further examination: is there any way the UK could achieve adequate confidence against pre-emptive attack in a system based on Type 45s? Or, to look at it from the opposite perspective, could the UK introduce enough doubt into the thinking of a potential attacker that it would be able to destroy simultaneously all the UK's nuclear-armed ships before they could launch their missiles, knowing that if it fails, it would experience severe retaliation?

Cruise missile options

Weaknesses of cruise missiles

A cruise missile system clearly has less of a global reach than a ballistic missile system, with a number of knock-on effects. The first is greater vulnerability: the area of ocean which the platform (the submarine or ship) can patrol in, and which the adversary can monitor and defend, will be much reduced. The second effect is the risk of escalation: the need to patrol close to a potential target state risks provoking a response. The third effect is reduced flexibility: if a potential target is far from the UK, the submarine or ship will take time to move into firing position; and a single submarine or ship cannot simultaneously threaten, or deter, two states more than a few thousand miles apart. A fourth is that some targets may be simply out of reach (though with the longer-range cruise missiles, this constraint may be more theoretical than real). Finally, there is the increased running cost of maintaining a submarine or ship close to a potential target far from the UK (which if it required new or additional bases, would add very significantly to the costs).

Cruise missiles also tend to be more vulnerable to interception in flight than ballistic missiles, due to their lower speed and altitude. Cruise missiles typically fly at around 500mph and can be shot down by fighters and advanced air defence systems; though they attempt to use 'stealthy' tactics such as contour-hugging flight and other measures to evade such defences, and defending against cruise missiles is not straightforward. The slower speeds of cruise missiles also enable them to receive targeting data in real time, a compensatory advantage. The development of ballistic missile defence systems could change this relative calculus: there is an emerging literature that suggests the relative advantage of ballistic missiles may in future be eroded.[17]

Cruise missiles carry only a single warhead, while Trident ballistic missiles carry multiple, independently-targeted warheads. This means that to create a similar level of confidence in the ability to overwhelm defences, a very large number of cruise missiles may have to be fired in a very short space of time. (This is an example of how – as discussed above – a perceived requirement to guarantee defeat of the most sophisticated defences almost rules out a system based on cruise missiles, in favour of ballistic missiles with their ability to deliver a large number of warheads on a given target in a very short space of time.)

Any cruise missile option will require the UK to (re)develop a different warhead to the current Trident warhead. AWE Aldermaston may well already have a design for such a warhead on its shelves, and facilities there should allow the Ministry of Defence to develop them without the need for testing (now banned under the Comprehensive Test Ban Treaty (CTBT)), with an acceptable level of confidence. Developing a warhead for a cruise missile should in theory be somewhat simpler technically than developing a new warhead for a ballistic missile, which has to endure greater stresses in flight and to detonate reliably at high-speed re-entry. One could assume the costs would be similar to, or slightly higher than, the costs of the less ambitious modifications to the current warhead planned for the 2020s. The Trident Alternatives Review estimates the cost of developing or adapting a warhead for any cruise missile at £8-10 billion, compared to £4 billion for the planned modifications – there is no way to verify this, though it appears high. In terms of timing, as noted above, the Trident Alternatives Review suggested that AWE would take a minimum of 24 (17 plus 7) years to design and manufacture a warhead for a new system such as a cruise missile. Again, it is hard to verify these estimates, but they appear to be conservative.

All cruise missile-based options suffer from ambiguous 'signalling'.[18] If the UK operates both nuclear and conventional cruise missiles, there is a risk of a potential adversary being in doubt as to whether an incoming missile represents a nuclear attack; in the case of nuclear-armed adversaries, this might increase the risk of them retaliating to a conventional strike with nuclear weapons. However, it should be noted that the US operated both conventional and nuclear cruise missiles for some decades (before the withdrawal of nuclear cruise in 2010), during which time 'signalling' was not considered a serious problem; that Russia still does; and that the US is developing conventional ballistic missiles, which would reintroduce ambiguous signalling. We might also consider how likely it would be that a potential adversary would really mistake the launch of a conventional cruise missile for a nuclear-armed cruise missile, if the UK maintained a clear and consistent policy of only using nuclear-armed missiles in extreme circumstances of self-defence.[19]

Cruise missiles from submarines

Russia operates submarine-launched dual-capable cruise missiles (SS-N-21) launched from torpedo tubes and Israel may also do so. The United States, as noted above, has recently withdrawn its submarine-launched nuclear-armed Tomahawk cruise missiles. Though not included in the 2006 White Paper, submarine-launched cruise had been one of the most frequently discussed alternatives in the UK debate in recent years prior to the publication of the Trident Alternatives Review, and the option most often favoured by those who believe that a minimally effective or credible nuclear weapons system can be built at significantly lower cost than current plans.

The Astute-class submarines (described above) were originally designed for Anti-Submarine Warfare and protecting the UK's SSBN fleet, though they have since taken on a wide range of additional roles: operations in support of naval or amphibious task forces, operations against hostile maritime forces, covert insertion of special forces, and – most relevant to present purposes – cruise missile strikes against land targets, as demonstrated in the 2011 Libya campaign. The concept of dual-use Astutes operating with nuclear and conventional cruise missiles introduces further complexity (compared to the previous option of adapting additional Astutes to fire Trident missiles), including the following variables:

- whether or not CASD would be maintained;
- the number of Astute-class submarines to be converted;
- the implications for the conventional tasks currently carried out by the Astute fleet; and,
- the type of nuclear-armed cruise missile to be procured.

As noted above, the UK has committed to building seven Astute-class submarines, of which three have been completed, with the remainder planned to enter service over the next ten years. They have a design service life of 25 years (though with life extension this could turn out to be longer), and are powered by the latest version of the PWR2 reactor, "Core H", apart from the last (seventh) Astute submarine, which is planned to use the PWR3, the reactor slated for use in the Successor submarine.

If the requirement of CASD is to be maintained, at least four adapted Astutes would have to be allocated to the task.[20] Some additional Astute-class submarines would probably have to be manufactured to replace some of the lost conventional capacity, though in pure military-requirement terms, this could be less than four, since the current planned size of the Astute fleet is driven at least in part by the requirement to maintain the domestic submarine industry at critical mass.

If the requirement of CASD is dropped, then two or more of the Astute fleet could be converted to dual-use, carrying either conventional cruise or nuclear cruise, or both, depending on the mission. The end of CASD would itself significantly reduce the demand on the (non-nuclear-armed) Astute fleet, since some of that demand is currently the protection of the continuous Trident patrols.

A system based on nuclear-capable cruise missiles with similar specifications to those already deployed on the Astutes, assuming they could be procured, would keep the costs and complexity of conversion to a minimum. Each Astute currently carries around twenty Block IV Tomahawk cruise missiles,[21] together with roughly the same number of heavy torpedoes. The missiles and torpedoes are both fired from horizontal tubes at the front of the submarine. Provided the TLAM-A can be procured from the United States, or the Block IV Tomahawk could be adapted to carry a nuclear warhead at acceptable cost, it would be relatively straightforward to convert a number of the Astute fleet to carry a number of these nuclear-armed cruise missiles in place of some or all of the conventional cruise missiles and some of the torpedoes (some of the latter would be retained for self-defence). Britain would probably look to acquire around 120 cruise missiles at around £1 million each for nuclear use. Adapting the Tomahawk Block IV, or the IV plus, to be nuclear-capable should be feasible without excessive cost, assuming the US is co-operative.

As with the option of adapting Astutes to launch Trident (see above), abandoning the replacement SSBNs would lead to immediate procurement savings, and significant savings on running costs. The planned new fleet of three or four SSBNs is currently costed at £11-14 billion. The unit cost of an Astute is £1.2 billion. Building four adapted dual-use Astutes is still likely to cost very significantly less than £11-14 billion. If the requirement of CASD is dropped, the procurement cost would be lower still. The only question is whether these savings would be entirely off-set by the costs of a new or adapted warhead (see above).

Again, as with the option of adapting Astutes to launch Trident, the apparent cost advantages would have to be considered in the round alongside the implications for the UK's submarine industry; but the Astute production timeline could be slowed, and a combined fleet of, for example, ten boats (of which two or more would be adapted for dual-use),[22] with an expected service life of 30 years, would allow for a realistic continuous 'drumbeat' of domestic submarine production with a minimal gap between generations.

Running costs would also be significantly lower, with smaller crews and the ability to conduct dual-use patrols – as much as half that of the current SSBN planned running costs.

Strengths

In addition to cost (see above), though more vulnerable than an SSBN, an SSN remains less vulnerable than most other systems. As noted above, an Astute-based system would not have the level of stealth envisaged for the new purpose-built SSBNs, though the Ministry of Defence has previously described the Astute-class as having 'unprecedented' stealth characteristics. Even if CASD is dropped, if the nuclear-armed and non-nuclear armed Astute-class submarines were impossible to differentiate externally (or by their patrol patterns) then a potential adversary would have to be sure of eliminating all patrolling and docked submarines to prevent a retaliatory attack.

A fleet of dual-use submarines, able to operate in a nuclear-armed role or a conventional role, obviously gives more flexibility. As with the option of adapting Type 45s discussed above, in an era when military platforms are growing increasingly expensive, thereby limiting the number even a country with relatively high defence spending can afford, employing dual-use platforms is generally a good strategy.

Weaknesses

An Astute carrying a maximum of around 30 single-warhead cruise missiles with two launch tubes would represent a very significant reduction in capability compared to the planned SSBNs, not only in numbers but also speed of launch.

The requirement to be closer to the target (because of the limited range of the cruise missiles) would limit the flexibility of the system (compared to one based on ballistic missiles) and would also make the submarines more vulnerable once they have revealed their position when the first missile is launched.

The Trident Alternatives Review identified a significant technical challenge around shielding crew from radiation in a system using existing horizontal launch tubes, since the crew quarters are very close to the stored torpedoes. The Review suggested that designing a new low-radiation warhead for horizontal launch in existing torpedo tubes would take 34 years, compared to 24 years to design a new warhead for a vertical-launched cruise missile. As noted above, these estimates are unverifiable and appear very conservative.

However, these weaknesses could be mitigated by a more radical adaptation of the Astute design, to insert an additional section of similar diameter to the rest of the submarine with a vertical 16-tube launch system, enabling greater crew protection and a far higher rate of fire – though this would come at significant additional cost.

The version of this option which would unlock the most savings – a dual-use system which involved dropping CASD – faces the objection of any option which drops CASD, i.e., it thereby sacrifices invulnerability to pre-emptive attack. However, as noted above, total invulnerability to pre-emptive attack should arguably be seen, not as a non-negotiable criterion, but as one advantage to be weighed against other factors, including cost. Even more than an option using Type 45s, the questions around vulnerability warrant further examination. With an Astute-based system not operating CASD, could it be possible for the UK to reach an acceptable level of confidence against pre-emptive attack – or, to look at it the other way, could sufficient doubt be introduced into the thinking of a potential attacker about its ability to simultaneously destroy the UK's entire nuclear capability?

Dropping CASD could be combined with a policy of having the submarines and missiles deliberately spread – including some in a newly-hardened AWE – rendering it more difficult for an adversary to be confident of destroying all of them with a pre-emptive strike. Of course, the costs of adapting additional bases, or hardening AWE, would have to be offset against the projected cost savings of dropping CASD and reducing the number of submarines; but the net savings (even with vertical launch tubes) are still likely to be significant – provided the warhead costs are not excessive.

As with the option to adapt Astutes to launch ballistic missiles (discussed above), the apparent cost advantages would have to be considered in the round alongside the implications for the UK's submarine industry; though it appears that a steady, albeit slower, drumbeat could be maintained.

As with options involving dual-use surface ships, a fleet of Astute submarines designed for dual nuclear and conventional use would be very demanding in the training required for the crews; dual-use platforms have, however, been operated by more than one nation in the past.

More generally, this option suffers from the generic weaknesses of all options involving a switch to cruise missiles. Even the most capable version represents a very real down-grade of capability. Nevertheless, it would still be a weapon system which demanded respect, and it could offer an opportunity to move 'down the nuclear ladder' without exiting it entirely.

Cruise missiles from surface ships

We can assume that a feasible version of this option would be based on using the existing Type 45 ships or design (as discussed above in relation to the option of ballistic missiles from surface ships) and on procuring the TLAM-A or adapted Tomahawk IV plus cruise missile, or a missile which can similarly be procured at reasonable expense from the United States (as discussed above).

Adapting a Type 45 to launch a nuclear-armed cruise missile such as the Tomahawk TLAM-A, or adapted Tomahawk IV Plus, would be relatively straightforward. The current 45 Sylver A50 missile launcher on the Type 45 is slightly too short to launch a TLAM missile (which is around 5m long, compared to the Type 45's Sea Viper missiles at 4.2m long), but there is space for additional Strike Length Mk41 vertical launchers capable of firing all existing US cruise missiles and those in development. The UK Government confirmed in 2004 that:

'If a requirement for TLAM arises in future, the T45 has been designed with substantial space and weight margins to enable its capability to be upgraded through life. We currently estimate that up to 16 TLAM missiles could be mounted on a Type 45 destroyer.'[23]

Strengths

The primary advantages are procurement and operating cost, and flexibility. The adaptation, by adding a new Strike Length Mk41 vertical launch system, would be relatively straightforward and affordable: more expensive than adapting Astutes to fire nuclear-armed cruise missiles from existing torpedo tubes, but still probably in the low billions of pounds. Dropping the requirement for CASD – a virtual necessity with this option – would also reduce or eliminate the need (assumed in the 2006 White Paper assessment of options involving surface ships) for additional Royal Fleet Auxiliary ships, destroyers or frigates, and one additional Astute submarine, to provide additional support and protection for the nuclear-armed ships. Even if it was deemed necessary to build additional Type 26 'Global Combat Ships' to compensate for any loss in conventional strength or flexibility, assuming these come in near their target cost of £250-£350 million each, the overall one-off costs of this option would still be unlikely to reach half of the one-off cost of the planned SSBNs (this excludes the cost of developing or adapting a warhead – see above). The through-life running and support costs of the Type 45s would increase (to take account of maintenance of the new missile compartment and the additional complexity and safety requirements of nuclear weapons) but again they would be relatively small compared to dedicated options. The additional cost of the necessary modifications to facilities at Faslane/Portsmouth was described in the White Paper as 'minor'.

A vertical missile launcher would give a superior rate of fire to a system based on horizontal launch from torpedo tubes on the Astute, thereby increasing the chances of overwhelming the defences of a potential target.

Finally, adding a Mk41 vertical missile launcher to the Type 45 would increase conventional capabilities, enabling the Type 45 to carry anti-ship weapons (in addition to the helicopter-launched anti-ship weapons they currently rely on).

As discussed above, in relation to the option of ballistic missiles from surface ships, using an existing platform brings strategic flexibility because the timelines are shorter than for many other options: provided a suitable cruise missile could be procured from the US, adapting the Type 45s should be relatively quick. Again, this option could therefore be adopted as a 'fallback' solution, allowing scope for strategic delay in the final decision on the way forward for the UK's nuclear weapon system until after 2020. If at that point the security and disarmament landscape still justifies maintaining the UK's nuclear weapons, and no better option has materialised, two or three Type 45s could be converted to fire nuclear cruise missiles from vertical launchers, and could conceivably remain in service until the late 2040s, similar to the plans for the new SSBNs.

Weaknesses

The weaknesses of surface ships (in particular their greater vulnerability compared to submarines) and cruise missiles (their shorter range, greater vulnerability to interception, restriction to a single warhead, and the greater uncertainty and cost of developing a new warhead) have been discussed earlier.

In relation to vulnerability, a similar approach could be taken as discussed earlier, by spreading the assets widely to make it as difficult as possible for a potential adversary to destroy them all in a single pre-emptive attack.

It is worth noting in addition, however, the particular challenge that a Type 45 carrying cruise missiles of a range similar to TLAM-A would need to patrol relatively close to the shores of a potential adversary (compared to a ballistic missile system): the combination of this proximity combined with the greater visibility of a surface ship compared to a submarine, would lead to far greater vulnerability, cost, and risk of escalation. Despite this, the flexibility of this option warrants serious consideration.

Cruise missiles from aircraft (from carriers or bases)

This option is relatively common among states with nuclear weapons and advanced air forces, and was explicitly considered in the 2006 White Paper. That assessment assumed twenty dedicated long-range aircraft at high readiness, each carrying four cruise missiles, plus twenty dedicated refuelling aircraft, to give the system global range. The proposed system had two bases – one new, one modified – with new storage facilities and a modified command system, and a new missile developed from scratch by the UK. This was (unsurprisingly) extremely expensive – twice the option of renewing the current SSBN system.

This is another illustration of how assumptions have strongly influenced the shape of the various reviews of UK options. It is worth at least examining how a different kind of aircraft-based system, one based on converting existing combat aircraft to dual-use, carrying an adapted version of an existing cruise missile, or a new cruise missile procured from the US, could be significantly cheaper and more flexible than current plans.

The US Air Force currently operates AGM-86 nuclear cruise missiles from its B-52H bombers, and is currently planning to arm the B2-A, the B-52H and their eventual replacement, the Long-Range Strike Bomber, with a new nuclear cruise missile currently in development. The UK may be in a position to purchase a number of these missiles.[24]

The most feasible aircraft option for the UK would be to fit nuclear-armed cruise missiles to the F-35, which offers stealthy characteristics to reduce vulnerability, plus carrier-borne capability, thereby providing similar global reach to a cruise missile based system using surface ships or submarines (though not the instant global reach of a system using ballistic missiles). The UK is currently planning to acquire 48 F-35s, expected to remain in service for many decades. The UK has currently selected the F-35B variant, designed for Short Take Off and Vertical Landing – having briefly switched to the F-35C (Carrier) version between 2010-2012. The F-35B has a mission radius from the carrier of 450 nautical miles; the F-35C a mission radius of 650 nautical miles or more. A refuelling capability (either stealthy or not) would increase the range, but at significant cost – though the Navy may decide to develop such a capability for conventional reasons anyway.

The feasibility of this option depends on procuring a nuclear-capable missile suitable for the F-35 – and on AWE being able to develop or adapt a warhead for the missile sufficiently quickly and at acceptable cost (on which see above).

No available cruise missile is small enough to fit into the internal weapons bays of the F-35B. If the UK switched back to the F-35C, its larger bays could carry (thereby preserving its stealth characteristics) a small cruise missile such as the Norwegian-developed Joint Strike Missile. At 4m long and 400kg, the JSM is far smaller than a missile like the AGM-86 (6m and 1500kg) and has a correspondingly much shorter range, of just over 100 nautical miles (compared to the 1350 nautical mile range of the AGM-86).[25]

Either variant of the F-35 can carry mid-sized cruise missiles (like the UK's Storm Shadow, around 5m) on external pylons. These will reduce its stealth characteristics, but will have longer range, thereby enabling the aircraft to stand off the target. However, even carried externally, neither the F-35B nor F35-C could carry a cruise missile with the range of an AGM-86 or TLAM-A. There is no indication that the next generation of cruise missiles under development will escape this fundamental trade-off between size, weight and range. So a system based on the F-35 would have limited range, 1,000 nautical miles at the most, and only in the case of the F-35C preserving its stealth characteristics.[26] More serious still, the US does not currently plan a nuclear-armed cruise missile for the F-35; adapting a UK warhead to an entirely different cruise missile may be prohibitively expensive.

Strengths

Assuming an acceptable solution could be found for the missile and warhead, adapting the F-35 fleet and the aircraft carriers would cost in the hundreds of millions of pounds; the running costs of the F-35 fleet would also be increased, but this would be marginal compared to the running costs of a dedicated submarine-based system. Rather than the high-readiness posture assumed in the 2006 White Paper, a system of readiness at 48 hours or longer (justified in the current security landscape) would greatly reduce the costs.

As with all dual-use systems, using existing platforms, this option has the benefit of flexibility. This option could also be considered in the context of Britain's relationship with NATO, complementing NATO's existing dual-capable aircraft system.

Weaknesses

Air-launched cruise missiles suffer many of the same shortcomings as other cruise missiles: the relative ease of interception, relatively short range (shorter in this case because of the size limitation on missiles carried by an aircraft like the F-35, though the range of the aircraft compensates for some of the reduction in range), and the difficulty of achieving sufficient scale to overwhelm defences, as each aircraft carries only one or two missiles, and each missile carries only one warhead.

Such a system would also be vulnerable to pre-emptive attack (though this could be mitigated by spreading assets, as outlined above), and would risk being escalatory in a crisis: stepping up readiness, and deploying to deter a potential adversary, would be very visible.

The most serious weakness is the lack of an available and affordable nuclear-capable cruise missile that could be carried on an F-35. However, if such a missile should become available in future, this option, while clearly not a high-capability system able to guarantee penetration of sophisticated air defences, could be a serious option if Britain were to consider moving towards a threshold status (see previous paper); or if it was pursued in combination with another option (see below).

Free-fall bombs from aircraft

This system was the basis of the UK's nuclear weapons from the early 1950s until the introduction of ballistic missiles from submarines in the late 1960s (a decision which was directly based on growing concern about the vulnerability of British aircraft to Soviet air defences). The UK retained free-fall nuclear bombs as a secondary system, but withdrew its last free-fall nuclear bomb, the WE-177, from service in the 1990s. This type of system is however still operated by several other countries, most notably the US.

The US operates the B61 family of warheads, several designs of which are planned to be consolidated into a modified version 12 to be carried both by strategic B2 and B52 aircraft, and by dual-capable stealthy F-35 aircraft operated by US allies in Europe. The B61-12 will also have a new tail-kit based upon the highly successful conventional Joint Direct Attack Munition (JDAM) guidance kit, which will give it an accuracy in the tens of metres and a range of 15 nautical miles from release. As above, a system based on carrier aircraft would provide similar global reach to a cruise missile-based system using surface ships or submarines.

The F-35A and F-35C (but not the F-35B) will each be able to carry two B61s in their internal bomb bay, preserving the aircraft's stealth characteristics. The US Air Force (USAF) has stated that it 'intends to deliver nuclear capability to all [F-35s] in Europe in the 2020 timeframe via the Block IV upgrade'. Adding nuclear capability to these aircraft is expected to cost over $300 million.

Given the very short range of a free-fall bomb, and the desirability of preserving the aircraft's stealth characteristics, this option would only be available to the UK if it switched back (again) to the F-35C variant.

It could then reintroduce a version of the WE-177 with US accessories (such as the tail-kit); or it could develop its own version of the B61-12, which in theory should be a simpler task technically than developing a new warhead for either a ballistic missile or a cruise missile, which have to endure far greater stresses in flight. The Trident Alternatives Review estimates the cost of developing or adapting a warhead for a free-fall bomb at £8-10 billion (the same as for a cruise missile), which seems excessive, although clearly there would be considerable uncertainty over cost.

Strengths

The cost of adapting the F-35 fleet would be minimal, and the cost of adapting the carriers to handle nuclear weapons would be relatively low. If the cost of re-introducing the WE-177s and modernising them including with a tail-kit was in the £2-3 billion range, rather than the £5-8 billion stated in the Trident Alternatives Review, the total one-off cost could be among the lowest of the systems considered here. The running costs of the F-35 fleet would increase, but the increase would be marginal compared to the running costs of a dedicated submarine-based system. Again, the system would be maintained at relatively low levels of readiness in current conditions, which would further limit cost.

Weaknesses

The range is the most limited of all the systems, being based on the range of the aircraft (650 nautical miles for the F-35C) plus 15 nautical miles, greatly limiting the useful scope of the system (though the aircraft could go further on a no-return mission, and the Navy may decide to acquire a stealthy refuelling capability for conventional reasons).

This option would share with the option of cruise missiles on F-35s (or other aircraft) the risk of being escalatory in a crisis: stepping up readiness, and deploying to deter a particular adversary, would be very visible. It would also share with that option the vulnerability of the aircraft, and the difficulty of achieving sufficient scale to overwhelm sophisticated air defences. The vulnerability issue could be mitigated, as with previous options, by spreading the assets, including keeping some aircraft at different bases, and some missiles in a newly-hardened AWE.[27]

The only reason for preferring it to a system based on air-launched cruise missiles is the potential possibility of re-introducing the WE-177, or procuring the B61-12, compared to the lack of an available nuclear-capable cruise missile suited to the F-35.

Conclusion

This chapter has reviewed possible options for a future nuclear weapon system for the UK: ballistic missiles from submarines, surface ships, land-based silos or mobile launchers; cruise missiles from submarines, surface ships and aircraft; and free-fall bombs from aircraft.

The Trident Alternatives Review went into costs and benefits in greater detail than this chapter, and highlighted many of the drawbacks of alternative systems. It concluded that there were viable alternatives to the current SSBN system, but that there remained considerable doubt as to their eventual costs, and that each one would suffer from lower capabilities relative to SSBNs. It should be noted, however, that a serious discussion of options requires more flexibility around three assumptions which lay behind previous UK decisions, and which tend to make SSBNs the inevitable outcome:

- the need to maintain CASD, or its closest equivalent;
- the necessity of invulnerability to pre-emptive attack; and,
- the necessity to defeat or overwhelm the most sophisticated air defences in the world.

These made sense during the Cold War, but are more questionable now; relaxing them opens up the options. The most significant savings are only accessible if the UK is prepared to relax these assumptions; and if a solution can be found to the warhead problem, including through cooperation with the US.

There is a possibility that the UK could consider a combined system, taken from the menu of options outlined here, such as a primary system of cruise missiles from dual-capable Astute-class submarines or Type 45 destroyers, together with dual-capable F-35s carrying WE-177 free-fall bombs. This kind of combined system, each part using existing assets converted to be dual-capable (nuclear and conventional), and with assets deliberately spread across a number of bases (and a newly hardened AWE) might be the best way to combine low cost with a reasonable degree of assurance of survivability against a pre-emptive attack, and sufficient scale to constitute a credible deterrent threat against any possible enemy.

It is also important to consider all these options not just in terms of their capability, but also their strategic flexibility. If the UK were to consider a system with reduced capabilities and more flexibility, perhaps on the way towards a threshold status as outlined in Paper 4, then other delivery systems than the dedicated SSBN become more attractive. Indeed, it would arguably make little sense to predicate serious moves down the nuclear ladder towards threshold status on a dedicated SSBN platform, given its very high cost and inflexibility.

Endnotes for Paper 3

1 Matt Cavanagh is a former special adviser who worked on defence issues in the Treasury, Ministry of Defence, and Downing Street from 2005 to 2010. He wrote this report in a personal capacity in 2012.

2 Trident Alternatives Review, Cabinet Office, 16 July 2013. Available here: https://www.gov.uk/government/publications/trident-alternatives-review

3 *Bulletin of the Atomic Scientists* estimate, cited in 'French nuclear deterrent', Commons library note, June 2010.

4 The life extension programme for the Minuteman III silo-based missiles cost $7 billion (SIPRI 2010, p338). The life extension of the Trident D5 is currently estimated at $4 billion for 108 missiles, 2008-2012 (SIPRI 2010, p. 340).

5 For example, the costings of most of the options in the Alternatives Review are inflated by adding the costs of building two new SSBNs to 'bridge the gap' created by these timelines for new warhead development – given this, it is hardly surprising that none of the options come out cheaper than current plans of building 4 SSBNs.

6 Initial Gate Parliamentary Report, May 2011.

7 The size of the UK's attack submarine fleet has – like many other defence capabilities – been progressively scaled back over the years, driven in part by increasing unit costs, from 15 during the Cold War to 12 in the 1990s, to 10 in the 1998 SDR, and now to 7, confirmed in the 2010 SDSR.

8 The Commission's final report goes into some detail on the costs and benefits of maintaining or dropping a continuous at sea posture in Chapter 2. The Commission was unable to come to a united view on the matter.

9 The precise dates would depend on which two submarines were chosen.

10 Some of these potential options are described in the Trident Alternatives Review (p.18) but are presently at an early stage of development.

11 The risk could be mitigated by re-starting the reactors with more of an overlap with the submarines in service, but this would simply reduce the length of delay which this option generates, thereby reducing its value.

12 Philip Dunne, Minister for Defence Equipment, Support and Technology, 20 September 2013.

13 It was a shortcoming of the options work which lay behind the 2006 White Paper that none of the options explicitly considered there involved dual-use capabilities.

14 In previous decades, silo-launched ballistic missiles had longer range and greater accuracy than submarine-launched ballistic missiles, but in successive generations of submarine-launched ballistic missiles this capability gap has been closed.

15 In a 'launch-on-warning' posture, missiles would launch as soon as an incoming attack is detected.

16 The other, less likely option of acquiring second-hand US Minutemen III or similar (see above) would be at least as expensive.

17 See, for example, Dennis M. Gormley, 'Missile Contagion: Cruise Missile Proliferation and the Threat to International Security', (Annapolis, MD: Naval Institute Press, 2008), p. 9.

18 Lee Willett, 'The Future of the United Kingdom's Nuclear Deterrent: Cost and Cruise Missile Issues in the 2006 White Paper', RUSI; Toby Fenwick, 'Dropping the Bomb', Centre Forum, 2012.

19 Reiterated in the 2010 Strategic Defence and Security Review.

20 As noted above, there is a live discussion of whether three or four of the new design of submarine would be required to maintain CASD; but the additional maintenance needs of the Astute mean four would be the minimum.

21 The UK bought over 60 Block IV missiles, which were delivered in 2006 and entered service in 2008, at a unit cost of around £600,000.

22 The Trident Alternatives Review suggests a range of 10 to 18 boats, the upper end of which appears excessive.

23 Written parliamentary answer, Mr. Ingram to Dr. Julian Lewis, 9 March 2004, Hansard Col 1407W

24 See Hans M. Kristensen, 'B-2 Stealth Bomber to Carry New Nuclear Cruise Missile', 22 April 2013, http://fas.org/blogs/security/2013/04/b-2bomber/

25 Similar range to the Tomahawk TLAM-A, also around 6m and 1,500kg. For comparison, the French nuclear-armed airlaunched cruise missile, the ASMP, which is roughly mid-way in size and weight between the US and Norwegian missiles, has a range of a few hundred kilometres.

26 The F-35B would have a mission radius of 450 nautical miles, plus 200-500 miles for a new generation small cruise missile carried externally (thereby forfeiting stealth characteristics); the F-35C, would have a mission radius of 650 nautical miles, plus 200 miles for a JSM carried internally; or plus 200-500 miles for a new generation small cruise carried externally.

27 Madelyn Creedon, Assistant Secretary of Defense for Global Strategic Affairs, and Andrew Weber, Assistant Secretary of Defense for Nuclear, Chemical, and Biological Defense Programs, Joint Statement On Fiscal Year 2013 National Defense Authorization Budget Request for Department of Defense Nuclear Forces Programs Before the U.S. Senate Armed Services Strategic Forces Subcommittee, March 28, 2012, p.13.

The Trident Commission

An independent, cross-party inquiry to examine UK nuclear weapons policy

July 2014

Background papers to the Concluding Report

We are living through a period of dramatic change in international affairs with new powers emerging, stubborn nuclear proliferation risks both within the community of states and potentially amongst terrorist groups, renewed commitments to multilateral nuclear arms control and disarmament, and growing financial pressure on defence budgets. The UK has to decide priorities as we simply cannot afford to keep high-cost legacy systems that have little relevance to emerging new threats, or old ones that stubbornly reappear. Does the renewal of Trident fit the bill?

This report arises from a three year review of Britain's current nuclear weapons policy led by Sir Malcom Rifkind, Lord Browne and Sir Menzies Campbell. It met at this most critical of moments making use of the opportunities afforded by the government's decision in 2010 to delay the construction of the replacement submarines until after the next election.

The Commission comprised eminent members of the British political, security, diplomatic and scientific community, and this report has been agreed by consensus. It has been long-awaited as an expression of informed opinion approaching the critical strategic issues associated with nuclear weapons from a national security perspective.

The report attempts to answer the three key questions:

- **Should the United Kingdom continue to be a nuclear weapons state?**
- **If so, is Trident the only or best option for delivering the deterrent?**
- **What more can and should the United Kingdom do to facilitate faster progress on global nuclear disarmament?**

Crucially, these three inseparable questions do not lend themselves to simple, easy answers. Nevertheless, this report summarises the extensive work of the Commission, and presents its answers in an accessible manner.

For more on the work of the Commission, back ground papers, previous briefings and written evidence please visit its website at: www.basicint.org/tridentcommission

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