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Discussion Paper Issues Related to Ageing Nuclear Warheads

Overview

All states with nuclear weapons are faced with decisions related to ageing warheads. It is essential to have a clear understanding of the common problems, and to explore alternatives to warhead modernisation and redesign, if we are to avoid locking states with nuclear weapons into prolonged reliance on nuclear weapons through lengthy investments in upgrades. The general principles are the same across nuclear weapons states, and a great deal of information can be—but rarely is—discussed in declassified forums.

Challenges

Some of the materials used in nuclear warheads have characteristics that make them subject to possible instability as they age. In some cases the combinations of materials used may pose particular problems for ensuring reliability over the longer term. In addition, many of the warheads in global stockpiles were built without modern safety features such as insensitive high explosives which specifically hedge against a disastrous accident.

Nuclear weapons states rely upon advanced computational and experimental work to continually test the reliability of their arsenals, since most are bound to not conduct nuclear weapons tests under the Comprehensive Test Ban Treaty¹. As a result of this work, changes are sometimes made to aspects of the warhead, for example in replacing components with improved functionality or substituting some materials with higher performing ones.

However, not all proposed changes to warheads are solely for safety or reliability. Some represent an increase in the warhead capability. Moreover, some changes may be motivated by a perceived need to maintain a particular skills base.

Analysing the motivations for proposed changes poses a challenge for decision makers. In trying to make such assessments, they are at a clear disadvantage. In most countries they appear to rely upon the advice of (a) the weapons labs themselves and (b) those companies concerned with providing systems, expertise, materials or components for analysis of whether or not and why upgrades and/or redesigns are necessary or prudent. The US is one of the most open countries in this respect, and there have been recent cases where outside experts have successfully refuted technical claims made by the weapons designers.

¹ Most states with nuclear weapons have signed the CTBT, though it is not yet fully ratified and as a result has not technically entered into force

There has been a significant rhetorical shift recently, as more and more senior figures are holding open the option for an eventual world free of nuclear weapons. Ongoing modernisation of nuclear stockpiles may stand in the way of any possible trend toward disarmament. Such modernisation also can provide an incentive for other states to acquire their own nuclear weapons.

US-UK Warhead Cooperation: A Unique Case Study

The US and UK, in a unique collaboration, have cooperated on nuclear weapons since 1958 (indeed, this cooperation included earlier joint work on the Manhattan Project itself). Because much more information and details are available today about nuclear weapons in the US political system, one can surmise from US sources a great deal about the more secretive UK programme.

Although some studies argue that the UK's warheads "can be maintained in service indefinitely through a programme of inspection, refurbishment, and remanufacture within original specifications"², the UK government estimates that its warheads will last at least until 2020.³ Taking this official estimate, research, design, and production lead-times mean that decision makers will soon be faced with a decision about modernizing or replacing the warheads.⁴ In December 2006, UK Defence Minister Des Browne said that this decision is likely "in the next parliament" and that no changes were likely "in the next 5 years."⁵ Browne also said that a Warhead Pre-Concept Working Group will have approximately 10 million pounds funding each year for 2007-8, 2008-9, and 2009-10.⁶ Therefore, it is reasonable to assume that the UK government hopes to have the relevant decisions made, and a modernisation or replacement warhead programme in place, by late 2010 or 2011.

Question: Will the UK warhead need to be replaced by 2020? What are the driving technological reasons for this perceived need and the proposed timings?

The current UK warhead is widely believed to be based upon the US W76 design. Hans Kristensen of the Federation of American Scientists recently released a declassified report, obtained after eight years of processing under the US Freedom of Information Act, which

directly links the warhead designs on U.S. and U.K. Trident missiles...[T]he British warhead modification...is similar enough to the U.S. W76 warhead to

² See for example Milne, Beach, Finney, Pease and Rotblat: 'An End to UK Nuclear Weapons', British Pugwash Group, London (2002).

³ The Future of the United Kingdom's Nuclear Deterrent: Defence White Paper 2006 (Cm 6994), December 2006, <http://www.mod.uk/DefenceInternet/AboutDefence/CorporatePublications/PolicyStrategyandPlanning/HeFutureOfTheUnitedKingdomsNuclearDeterrentDefenceWhitePaper2006cm6994.htm>

⁴ Ibid.

⁵ Des Browne, 18 December 2006, Hansard, Col 1486W, <http://www.publications.parliament.uk/pa/cm200607/cmhansrd/cm061218/text/61218w0010.htm#06121849000671>.

⁶ Des Browne, 28 November 2007, Hansard, Col. 453W, <http://www.publications.parliament.uk/pa/cm200708/cmhansrd/cm071128/text/71128w0004.htm#07112863002328>.

make up an integral part of the W76 engineering, design and evaluation schedule....Specifically, the document shows that between 1999 and 2001, work on five of 13 'W76 needs' involved the 'U.K. Trident System.' These activities included vibration and point shock models, impulse models, impulse and point shock tests, vibration tests, as well as 'TSR [thermostructural response] and Blast Models'.⁷

There have been press reports that the UK has already taken steps to explore a new warhead, dubbed the High Surety Warhead, based on the U.S. Reliable Replacement Warhead.⁸ It is difficult to know, due to secrecy, how much these reports have picked up on ongoing work with the US (for example on plutonium ageing), how much is UK cooperation on the Reliable Replacement Warhead, and how much is work related to the Warhead Pre-Concept Working Group.

The US Experience

It is possible that forthcoming decisions on the UK warhead will mirror in some ways the debate recently held in the United States on the Reliable Replacement Warhead, which was designed to address perceived problems with the W76. Problems claimed with the W76 included: efforts to introduce a new fuse with ground burst capability to "enable [the] W76 to take advantage of [the] higher accuracy of the D5 missile."⁹ (this upgrade was made independently of the RRW, and is being incorporated into the W76-1);¹⁰ introduction of insensitive high explosives to increase the safety of handling the weapons; permissive action links to require appropriate authorisation to fire the weapons, and elimination of the highly toxic beryllium with nontoxic, recyclable waste.¹¹ Earlier reports warned of a possible 'common mode' failure in the W76.¹² Plutonium ageing was once given as a possible incentive for this work, but a November 2006 report by the highly influential JASON advisory group stated that most pits have credible lifetimes in excess of 100 years and 'clear mitigation paths' exist for those with assessed minimum lifetimes of 100 years or less. In other words, "pit lifetimes do not at present determine warhead lifetimes."¹³

⁷ Hans Kristensen, "Britains Next Nuclear Era," Strategic Security Blog, 7 December 2006, www.fas.org/blog/ssp/2006/12/britains_next_nuclear_era_1.php.

⁸ See for example, Michael Smith, "Revealed: UK develops secret nuclear warhead," *The Sunday Times*, 12 March 2006, www.timesonline.co.uk/tol/Print.do?articleId=740215 or Ian Bruce, "Britain in top-secret work on new atomic warhead," *The Herald*, 4 September, 2007, www.theherald.co.uk/misc/print.php?artid=1661681.

⁹ Department of Energy's 1997 Stockpile Stewardship and Management Plan, quoted in Hans M. Kristensen, "Administration Increases Submarine Nuclear Warhead Production Plan," Strategic Security Blog, Federation of American Scientists, 30 August 2007, http://www.fas.org/blog/ssp/2007/08/us_tripplis_submarine_warhead.php.

¹⁰ Ibid.

¹¹ See for example, comments by Bruce Goodwin, Associate Director for Defense and Nuclear Technologies, Lawrence Livermore Lab, in David Biello, "Special Report: New Nukes are Good Nukes?" *Scientific American*, 30 April 2007, <http://www.sciam.com/article.cfm?id=new-nukes-are-good-nukes>.

¹² See for example, Section III, "U.S. Nuclear Warhead Design Activities for Naval Strategic Forces, in "End Run: Simulating Nuclear Explosions Under the Comprehensive Test Ban Treaty," Natural Resources Defense Council, August 1997, www.nrdc.org/nuclear/endrun/er3.asp.

¹³ Linton Brooks to Sen. John Warner, 26 November 2006, http://www.nukewatch.org/facts/nwd/JASON_ReportPuAging.pdf.

Question: To what extent can other countries institute advisory boards similar to the JASON group in the US? How can greater openness about non-classified information related to ageing nuclear weapons be encouraged in other states with nuclear weapons?

After the release of the JASON report, which allayed concerns regarding plutonium ageing, the US Reliable Replacement Warhead programme has been voted down in Congress, not on technical, but on political grounds. According to analyst Martin Butcher, "The U.S. Administration failed to explain what purpose the RRW would serve." There are however still pressures to revive the programme.

Question: Are the political reasons given in the US against the RRW relevant for the future UK debate on nuclear warhead modernisation/replacement?

The UK Decision

As the UK moves toward making a political decision about its warhead programme, decisions relating to technological matters will have to be made. For example, a recent BBC Newsnight television programme highlighted the fact that UK weapons do not use permissive action links, and rely in effect on technology similar to that of bicycle locks.¹⁴ Another issue raised by UK weapons designers is that "some components used within the warhead are no longer available, either due to legislation (e.g. the Montreal Protocol on Substances that deplete the Ozone Layer) or cessation of manufacture for other reasons."¹⁵ Questions remain as to whether or not the UK warhead incorporates the fuse with ground burst capability, or if the changes that have been made in the US W76-1 should be made in the UK warhead. While the US JASON study presumably answered concerns about the possible degradation of plutonium within the nuclear package¹⁶, questions about the chemical high explosive and other materials still exist. A UK MoD report in 2006 raised concerns again that without insensitive high explosives, UK warheads are not 'one-point safe', meaning there is a danger of a partial detonation or radiation release in the event of a vehicle pile up or a crash. The report also raised concerns over a possible terrorist attack.¹⁷

Decisions concerning the modification or replacement of the UK warhead will inevitably be linked with decisions about possible missile upgrades. The US is upgrading its Trident missiles, and as the UK missiles are part of a common pool, it is expected the UK will participate in this programme, or at least will have to take account of the outcome of this programme. The new US missiles are likely to be

¹⁴ See for example, Merion Jones, "British nukes were protected by bike locks," BBC News, 15 November 2007, www.bbc.co.uk/go/pr/fr/-/hi/programmes/newsnight/7097101.stm.

¹⁵ Prof. Sir Keith O'Nions, et al., Nuclear Warhead Assurance Panel, "The Science of Nuclear Warhead Assurance," 22 January 2006, www.mod.uk/DefenceInternet/AboutDefence/CorporatePublications/ScienceandTechnologyPublications/InformationSheets/TheScienceOfNuclearWarheadAssurance.htm.

¹⁶ The UK has cooperated in plutonium ageing studies with the US, including at least one sub-critical test at the Nevada test site.

¹⁷ Rob Edwards, "Road crash could set off nuclear blast," *New Scientist*, 5 July 2006, www.newscientist.com/article.ns?id=mg19125594.300&print=true. This article contains the link to the MOD report.

bigger¹⁸ and the implications of this for the UK programme are not fully explored. Also, there have been recent reports that advisers to the US Strategic Command are urging a research and development programme for a US Trident Replacement. It originally was estimated that work would need to begin in 2016, for a submarine to be fielded in 2029. However, sources have been cited saying that initial funding will be sought as early as 2010.¹⁹ Two variants are under discussion, either a dedicated nuclear weapons bearing submarine or a variant of an attack submarine modified for a nuclear mission. The UK will watch this closely to be sure that the missiles remain suited for their own new Trident submarines.

Questions:

- ***Does the UK warhead currently incorporate the fuse with ground burst capability which is part of the new US W76-1? If not, would this fuse be part of a new UK warhead, and would this then represent a new capability and not simply an upgrade? (The fuse is designed to enhance hard-target kill capability, for use against underground bunkers, for example.)***
- ***Does the UK intend to introduce Insensitive High Explosives and/or Permissive Action Links to increase the safety of the warheads? What steps have been taken in response to the 1992 Oxburgh report on nuclear weapons safety²⁰?***
- ***How great an environmental threat is posed by the existence of beryllium in the warhead package or does the UK warhead not include beryllium?²¹***
- ***Does the UK warhead have this same 'common-mode' failure concern as the US W76?***
- ***To what extent would a move toward a new or modified UK warhead (and missiles) be driven by changes in the US missile design?***

¹⁸ Rob Edwards, "Oops! American Missile to Replace Trident is Too Big for Britain's Nuclear Submarines, *The Sunday Herald Tribune* (Scotland), 23 December 2007, http://www.sundayherald.com/search/display.var.1924101.0.oops_american_missile_to_replace_trident_is_too_big_for_britains_nuclear_submarines.php.

¹⁹ Elaine M. Grossman, "R&D Funds Needed for New Nuclear Weapons Submarine, U.S. Panel Advises," *Global Security Newswire*, 29 November 2007, www.nti.org/d_newswire/issues/2007_11_29.html#05F6F768.

²⁰ *Report on the Safety of UK Nuclear Weapons* (The "Oxburgh Report"), prepared by the Safety Review Group (chaired by the Chief Scientific Adviser to the Ministry of Defence), 12 February 1992.

²¹ While beryllium can be handled safely, Bruce Goodwin, associate director for defence and nuclear technologies at Livermore, extolled the benefits of creating a 'green' nuclear warhead in the planned RRW1. 'Because of the release of the weight requirement, we are able to use materials that are heavier but more environmentally benign.... We will be able to eliminate an entire process that produces 96 percent radiological toxic waste that has to be buried and replace it with non-toxic waste that is 100 percent recyclable. You replace it with something that quite honestly you could eat and be healthy.' Quoted in David Biello, "Special Report: New Nukes are Good Nukes?" *Scientific American*, 30 April 2007, <http://www.sciam.com/article.cfm?id=new-nukes-are-good-nukes>.

International Aspects

Many of the issues that arise with the ageing and security/reliability of nuclear warheads are faced by all states with nuclear weapons. A more open discussion about these topics could play an important role in reducing incentives for nuclear modernisation in other nuclear weapons states. Harold Agnew, a former director of Los Alamos National Laboratory, says that US reluctance to share warhead security technology was making the world more dangerous. "Lawyers say it's classified... That's nonsense. We should share this technology. Anybody who joins the club should be helped to get this.... Whether it's India or Pakistan or China or Iran... the most important thing is that you want to make sure there is no unauthorized use."²² The US has shared ideas and/or technology with countries ranging from the UK, Pakistan, Russia, and France, but has refused to share technology, for example, with China.

Questions:

- *What form should/could international cooperation on nuclear weapons safety and security take? Is there any benefit to holding a special technical session on these topics at an NPT PrepCom or the 2010 Review Conference, for example?*
- *What exactly is known about the status of ageing warheads in each state with nuclear weapons? Is it possible to draw up a summary of salient issues for each country?*

We know, for example, that the Russians have greater difficulty with the shelf life of their plutonium pits, which is in the range of 10-15 years, according to Oleg Bukharin, "because of the way the pits and warheads are designed and manufactured. In particular, because the fissile components are not completely isolated from the surrounding environment as they are being made (perhaps due to weld defects in pit casings), they are subject to corrosion and swelling. Russia therefore needs to remanufacture plutonium pits continuously."²³ Bukharin also states that other manufacturing and technology problems limit the lifetime of Russian warheads to 10-15 years, and that stockpile management problems emphasize the routine rebuilding of nuclear warheads.

Question: Is this still the case in Russia? If so, is there any way to use this constant pressure for rebuilding warheads as a means of encouraging disarmament toward lower numbers (i.e., to argue on technical grounds the retirement of older, less stable warheads)?

In France, similar problems exist. According to Roger Balleras, a former director of the Division of Military Applications at CEA, there have been problems with

²² David E. Sanger and William Broad, "U.S. Secretly Aids Pakistan in Guarding Nuclear Arms," *The New York Times*, 18 November 2007, www.nytimes.com/2007/11/18/washington/18nuke.html.

²³ Oleg Bukharin, "A Breakdown of Breakout: U.S. and Russian Warhead Production Capabilities," *Arms Control Today*, October 2002, www.armscontroltoday.org/act/2002_10/bukharinoct02.asp.

bonding, pollution [the mixing of metal with boost gas], and with plutonium metallurgy. French weapons were not built for a long stockpile life.²⁴

Question: Same as for Russia, in fact these questions can be asked of all states with nuclear weapons.

Oleg Bukharin calls for greater openness in warhead production capabilities as a means to decreasing fears of breakout.²⁵

Question: To what extent can multilateral discussions about warhead ageing serve as a confidence-building measure and a stepping stone toward greater disarmament?

Another part of the equation which will need to be addressed is the question of maintaining a skills base. As John Harvey of the US Nuclear National Security Administration said, “the expertise is aging faster than the plutonium.”²⁶

Question: Are there ways to address concerns regarding the skills base, which do not include modernisation or upgrading of existing warheads?

Further Questions:

- ***Are other states with nuclear weapons using the expected lifetime of plutonium pits as a justification for modernisation, and are there lessons from the US JASON study that are relevant for other states?***
- ***What are the issues related to short life components and are there ways to allay fears without introducing new warheads?***
- ***What is the current status of safety developments in the various states with nuclear weapons and what are the lessons learned since the US Drell Reports and the UK Oxburgh Report on ways to address safety concerns without altering designs.***
- ***What lessons can be shared about Enhanced Nuclear Detonation Systems, Fire resistant pits, Arming fuzing and firing, stronglinks, Insensitive High Explosives?***
- ***What special issues arise from the transport and storage of tactical nuclear weapons and are these issues incentives for further tactical nuclear disarmament?***
- ***What issues related to testing can be shared, for example, the miniaturization of safety elements vs. testing new designs, computer simulations, peer review, etc.***
- ***Are there ways in which further de-alerting can alleviate some safety concerns?***

Comments, corrections and any additional insights are welcomed and indeed encouraged! Sandra Ionno Butcher, 14 February 2008

²⁴ Roger Balleras, from interview with Garwin, Kidder, Paine, 11/4/94, <http://fas.org/rlg/paris94.pdf>.

²⁵ Bukharin, *Arms Control Today*, 2002.

²⁶ Quoted in Biello, *Scientific American*, 2007.

