Stepping down the nuclear ladder
Options for UK nuclear weapons policy

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Changing the Atomic Weapons Establishment

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1. Introduction

The Atomic Weapons Establishment (AWE) are currently embarked on an expensive programme of expansion. This paper raises a range of alternative futures for AWE and considers the potential for diversification.

2. Issues for AWE

1. Relationship with the US

Anglo-American collaboration over nuclear weapons has increased over the last decade and was set to expand further with the Reliable Replacement Warhead (RRW) programme.[1] The apparent gain to the UK from this relationship should be questioned. The quest to retain American support may push AWE towards a more radical modification of their warheads than would otherwise be the case.

2. Surety

One of the main justifications given for proposed modifications to UK and US warheads is that they will make them safer and more secure against unauthorised use. For example, AWE are currently collaborating with Lawrence Livermore Laboratory on the development of a new Multi-Point Safe warhead design.[2] However if both probability and consequence

[1] "If the US embarks on an aggressive transformation of the stockpile to smaller, safer, more reliable then that [US-US collaboration] will increase and accelerate". Interview with Glen Mara, LLNL. The Mutual Defence Agreement was amended in 2004 to give the UK access to use control information which was vital to collaboration on RRW. Interview with John Harvey, NNSA. http://csis.org/program/us-uk-nuclear-cooperation-after-50-years

[2] FY2010 Congressional Budget Request National Nuclear Security Administration, Department of Energy. http://www.cfo.doe.gov/budget/10budget/Content/Volumes/Volume1.pdf page 105. This indicates that multi-point safety would be inserted at an available opportunity, but JSP 538 Regulation of the Nuclear

are considered the greatest risks are not from an accident or terrorist incident but from the deliberate use of nuclear weapons.[3] It makes no sense to increase this greatest risk in order to reduce the lesser risks from accidents or terrorism. Measures such as de-mating and dismantling warheads offer alternative ways to minimise these dangers.

3. Unacceptable Damage

The decision to replace Polaris with Trident was partly based on mathematical calculations of what constituted unacceptable damage to the Soviet Union.[4] There is no publicly available indication of how the Ministry of Defence today calculate the level of nuclear destruction which they consider to be essential.

4. Expertise and modernisation

It has been acknowledged that the desire to retain and recruit key staff was a primary motive behind the RRW programme.[5] But this has been question by Richard Garwin and others who argue that the current Life Extension approach is adequate when backed by Science Based Stockpile Stewardship and where necessary re-manufacture.[6]

3. Potential steps for AWE

Step 1: Submarines armed but not on continuous patrol

If continuous patrols were ended the proportion of warheads stored on shore rather than on submarines could be increased, bringing some of the benefits of a de-mated system to part of the arsenal.

Step 2: De-mated Trident system

If all of the warheads were removed from submarines and stored in Coulport there would be ~~potential~~ safety and security benefits. The danger from loading/unloading missiles at the

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Weapon Programme suggests that multi-point safety cannot be incorporated into the current UK Trident warhead.

[3] The probability an accidental nuclear yield of 2kg TNT equivalent in the British nuclear weapons' programme should be greater than 1 in 100,000,000 per year (JPS 538 Regulation of the Nuclear Weapon Programme). The probability of nuclear war from a Cuban Missile Crisis type event has been estimated at between 1 in 5,000 and 1 in 20,000 per year and the overall probability of nuclear war at around 1 in 100 per year (Risk Analysis of Nuclear Deterrence, Martin Hellman, www.nuclearrisk.org).

[4] Factors relating to the future consideration of the future of the United Kingdom nuclear deterrent (Duff-Mason report), Part 2, Annex A Unacceptable Damage, 1978, DEFE 25-335, released by The National Archive and then withdrawn. Available on line at http://robedwards.typepad.com/files/unacceptable-damage.pdf

[5] Interviews with Stan Orman, ex-AWE, and Pete Nanos, Dept of Defence. http://csis.org/program/us-uk-nuclear-cooperation-after-50-years

[6] Testimony to the House Energy and Water Development Appropriations Subcommittee by Richard Garwin, 17 March 2009. http://www.fas.org/rlg/03172009%20TEST1a.pdf

EHJ would be reduced. All the warheads would be stored in one facility, simplifying security requirements.

There might be less concern about warhead reliability in a de-mated system. It would be easier to carry out non-intrusive surveillance of all the warheads. Detailed surveillance and replacement of Limited Life Components, which are outside the Nuclear Explosives Package, could also be carried out on the entire arsenal. The warheads would be stored in an environment which is easier to control than a missile launch tube. Tritium reservoirs could be rotated on a shorter cycle than at present. Replacing tritium is a simple way to improve warhead reliability.

The safety and security hazards associated with transporting weapons by road would be reduced if the warheads were all stored at AWE rather than Coulport. Storing a large number of warheads at AWE would only be possible if a new store was build. In this scenario the day to day security requirements for Coulport could be reduced.

Step 3: Dismantled nuclear arsenal

Dismantling all nuclear weapons and retaining the components at AWE would achieve the benefits, listed above, of returning complete weapons to AWE. In addition it would reduce the risks associated with refurbishing or replacing nuclear warheads. There would be no ongoing risk of an accidental or unauthorised detonation of a nuclear weapon. The high explosive and plutonium pit would be stored separately. There are probably adequate facilities for both at AWE. The Canned Sub Assemblies could be stored as complete units or they could be dismantled and their various exotic parts stored separately. There may be a need for improved storage facilities for some warhead components.

Each component could be stored in an optimum environment. This would minimise the risk that they would degrade. Separating the parts would remove the risk of chemicals moving from one component to another, which is currently a major concern. Surveillance of the all the individual parts could be carried out as required. It would be easier to carry out surveillance and to identify problems from aging. As a result the reliability of the arsenal might be greater than at present.

Assembling a warhead at Burghfield takes around 3 months.[7] The current assembly facility and its proposed replacement can probably assemble 30-50 warheads per year.[8]

Step 4: Virtual nuclear arsenal retaining AWE

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[7] Reply by Dr Tom McLean, AWE, The Progress of the Trident Programme, House of Commons Defence Committee 5th report 1988/89, HC 374, 21 June 1989, page 5.

[8] The new Project Mensa facility at Burghfield is designed to have a similar capability to the old assembly facility. The maximum assembly rate for Trident warheads was probably between 30 and 50 per year at a time when the facility was also refurbishing WE 177 and Chevaline warheads.

If the components of the current warhead were not retained, AWE could still be kept going to retain the potential to produce warheads. Production of plutonium pits takes around 9 months.[9]

Step 5 : Virtual nuclear arsenal without AWE

Even if the AWE site was decommissioned Britain could still retain a virtual nuclear capability. Japan is considered to be a virtual nuclear power because it has large stocks of plutonium and facilities to enrich uranium. It has a high level of expertise in nuclear power. These materials and skills could potentially be used to produce nuclear weapons. Britain has a large bank of knowledge of how to build a range of nuclear weapons, including data from nuclear tests. Even if AWE were closed down it would be easier for Britain to produce nuclear weapons than it is for Japan.

Step 6: Active elimination of expertise and material

A final step would be to go beyond the retention of a virtual nuclear capability and to actively destroy the records of how to build nuclear weapons. Nuclear materials could also be transformed so they could not easily be used for weapons.

While the reduced-readiness options above would all involve programmes to capture and retain knowledge, this approach would involve the opposite. An example was South Africa's destruction of not only its nuclear weapons facilities but also its nuclear records at the close of the apartheid era.

4. Timescale to restore capability

The following is a rough guide to how long it might take to arm one submarine:

	12 warheads	**48 warheads**
Complete warheads all at Coulport	1 week	2 weeks
Complete warheads all at AWE	3 weeks	6 weeks
Dismantled warheads all at AWE	5 months	15 months
Virtual arsenal, retain AWE	2 years	2 ½ years
Virtual arsenal, AWE decommissioned	10 years	11 years

The first option assumes that a submarine is in Coulport ready to be loaded. The second option assumes that a nuclear convoy is available at short notice. The timings would be longer if this logistical support was at a lower state of readiness. In the case of a virtual arsenal the timings to restore a capability would depend on the sophistication of the type of

[9] Reply by Dr Tom McLean, AWE, The Progress of the Trident Programme, House of Commons Defence Committee 5th report 1988/89, HC 374, 21 June 1989, page 5.

warhead which was to be produced. The degree of restrictions imposed on Health and Safety grounds would also be a factor.

It is not correct to say that if Britain gave up its nuclear capability then the country could never again be a nuclear weapons' state. The question would be one of affordability. Restoring a lost or reduced capability would require a significant political and financial commitment. The degree of effort put in would affect how quickly nuclear weapons could be deployed.

5. Virtual arsenal retaining AWE

Examining Step 4, a virtual arsenal retaining AWE, provides a way of exploring the issue of maintaining expertise. In this scenario there would be no warhead components available for re-assembly, but some of the infrastructure and staff at AWE would be retained.

A key question would be "What sort of nuclear weapon might be reintroduced in future ?". A basic fission weapon would be substantially easier to produce than a thermonuclear device. It would be far easier to weaponise a warhead for a bomb to be dropped from aircraft than for a high-speed re-entry vehicle for a ballistic missile.

For example, the AWE might be asked to retain the potential to build 50 air-delivered fission warheads based on the design of the UK Trident primary, with approval from the US but with less American support than at present. With regard to the Nuclear Explosive Package the main emphasis would be on production rather than design. Some of the key manufacturing tasks would be: casting, welding and inspecting plutonium components; casting , welding and inspecting Beryllium components; production of EDC37 high explosive, including K10 energiser; and assembly of the warhead primary.[10]

AWE would want to be able to certify the re-manufactured warheads. This would be simpler if the production methods were kept as close as possible to those used to in the manufacture of Trident warheads. The US recently mounted a substantial effort to certify the re-manufacture of plutonium pits for the W88 warhead. Most of this work arose because the basic production technique had been changed, from wrought to cast plutonium.

AWE would need to be able to design and produce Neutron Generators for the new warhead. They could revive, certify and manufacture an existing UK design. Alternatively, after demonstrating their own abilities, AWE might be able to purchase Neutron Generators from the US.[11] In either case expertise in how to design and make these components would

[10] Plutonium casting is currently carried out in Bay 1 of A90 at AWE and Beryllium work in Bay 2.

[11] Neutron Generators are one of the "non-nuclear" components of the Trident warhead which are currently procured from the US.

be required. Certifying the performance of the Neutron Generator would be a critical factor in certifying the complete new design. One issue is the exact timing of when the Neutron Generator is initiated in the implosion sequence.

A new Arming, Fuzing and Firing (AF&F) system would be required. Some components, such as the firing sytem could be re-manufactured. Others, such as the safety mechanisms and fuzes, would need to be redesigned. Testing and certification of the new components would be required. Integration of the new AF&F as a complete unit would require additional work.

The UK Trident warhead would have to be weaponised for an air-delivered system. Adapting the warhead would present some challenges. But this would be much less demanding than the task faced by Aldermaston in the early stages of the Trident programme.

Retaining the potential to produce real warheads from a virtual capability would require detailed record keeping of current production processes, weapon codes, component designs and test and experimental data. It would also call for the retention of a minimum skill base within the UK, either at AWE or within wider society

6. Transferable skills and diversification

In 2004 the Armed Forces Minister Adam Ingram explained that AWE maintains a dialogue with industry and academia in order to achieve their nuclear weapons' mission and that some of their research could have wider application. He added - "Beyond this, it is not AWE plc's function within its contract with the MOD to diversify out of the core business it is required to undertake." [12]

In June 2008 a contract was issued to an offshoot of the Defence Science and Technology Laboratory to develop technology transfer at AWE. Their first task is to raise awareness within AWE of Intellectual Property issues and the potential for wider application of their research. A press release issued at the start of this project showed that AWE has had little experience of transferring their technologies to wider industry.[13] There is a lot of potential for diversification at AWE. Although little has been done at home, the UK has assisted projects to find alternative work for scientists and technicians in the closed nuclear cities in Russia.[14]

[12] Written Answer by Adam Ingram, Hansard 18 March 2004; This approach is confirmed in Technical Outreach at AWE, September 2008 http://www.awe.co.uk/Contents/Publication/69facf0AWE%20Technical%20Outreach.pdf

[13] http://www.ploughshareinnovations.com/news/documents/PSREFundPressRelease.pdf

[14] United Kingdom-Russia Closed Nuclear Cities Partnership, http://www.cncp.ru/eng/eng.shtml

In the United States there has been growing interest in changing the focus of Los Alamos, Lawrence Livermore and Sandia Laboratories. The suggestion is that they could function, as their titles suggest, as National Laboratories with a wide security remit rather than just nuclear weapon facilities. [15] Currently the proportion of their budgets dedicated to nuclear weapons' work ranges from 43% at Sandia to 60% at Lawrence Livermore.[16] Most of the additional work is on non-nuclear defence projects. One problem, which could also apply to AWE, is that it has been estimated that research work at the National Laboratories costs an average of two or three times more than private industry.[17]

There is currently a Work For Others (WFO) programme at the US laboratories. This gives government agencies and other organisations access to their facilities and expertise. WFO is also intended to encourage the technology transfer from the laboratories to industry. A key motive behind WFO is that this additional work will help the laboratories to retain key skills within their workforce.

A report on technology transfer at Los Alamos Laboratory shows the potential for researchers at the laboratories to support projects other than the production of nuclear weapons.[18] Examples include: nanotechnology with potential applications in solar energy and energy storage; climate modeling of the oceans and sea ice; developing alternatives to oil-based materials; research into AIDS; and satellite imagery analysis following natural disasters.

Areas where the skills required at AWE merge with those required in the wider economy include science, engineering and Information Technology. There are particular overlaps with the civil nuclear industry and with conventional military research and production.

The skills required to produce a new fuzing system for an air-delivered nuclear weapon are similar to those employed in the development of fuzes for conventional weapons. Much of the explosives and explosives safety expertise needed in the nuclear weapons programme can be found in the conventional military sector. It should be possible for AWE to take on more conventional military work or, if AWE were closed, for some key skills to be retained in the conventional defence sector.

Nuclear safety and monitoring skills used in nuclear weapons' production are similar to those in the civil nuclear sector. AWE are currently working on their own decommissioning programme and the skills and technologies involved have potential applications in the wider nuclear industry.

[15] Leveraging Science for Security: A strategy for the Nuclear Weapons Laboratories in the 21st Century, Frances Fragos Townsend, Lt Gen Donald Kerrick, Henry L Stimson Center, March 2009. http://www.stimson.org/cnp/pdf/Leveraging_Science_for_Security_FINAL.pdf

[16] Townsend & Kerrick, page 14

[17] Townsend & Kerrick, page37

[18] Technology Transfer Report 2007/08 LANL; http://www.lanl.gov/partnerships/

A current area of expansion at AWE is Information Technology. Some of these are skills in scientific and engineering modelling, others are in IT itself. In both cases there are substantial overlaps with the requirements from the wider economy. For example the visualisation capabilities, with large screens showing details from complex computer simulations, can be used in the health sector and many areas of industry. The super-computers at AWE and the personnel who programme them could be used for climate modelling.

Current material science work looks at ageing problems with existing materials and the properties of potential replacement materials. There is significant potential to use the same capabilities to develop new materials for the wider industrial world.

7. Verification and Non-Proliferation

One area where research could be expanded is work on verification and non-proliferation. The UK has already been involved in developing methods and procedures for verifying nuclear disarmament.[19] One focus has been on how to verify nuclear disarmament without compromising security considerations.[20] Radiation monitoring techniques have been developed to detect the presence of nuclear weapons. The UK and Norway conducted a series of joint exercises between 2008 and 2009 to develop ways of verifying nuclear disarmament, with the UK inspecting a mock nuclear weapon facility in Norway.[21] There has been some similar research conducted by the US Laboratories.[22]

AWE has developed capabilities to detect nuclear tests including radionuclide detection stations on four British dependent territories around the world and a seismology team at Blacknest. This work supports the implementation of the Comprehensive Test Ban Treaty.[23]

There is scope for the UK's work on verification and non-proliferation initiatives to be increased. The US Department of Energy budget request for Non-Proliferation work in FY

[19] Verifying Nuclear Disarmament: A Role for AWE Aldermaston, T Milne and H Wilson, British Pugwash Group 1999; Road to 2010: Addressing the nuclear question in the twenty first century, Cabinet Office, July 2009, Cm 7675, page 40

[20] A summary report by the Ministry of Defence on the study conducted by the Atomic Weapons Establishment Aldermaston into the United Kingdom;s capabilities to verify the reduction and elimination of nuclear weapons. http://www.mod.uk/NR/rdonlyres/3B3D7417-EAE1-487F-A0BB-891E841FA973/0/nuclearweaponsverification.pdf

[21] Presentation on the UK-Norway Initiative on Nuclear Warhead Dismantlement Verification to the NPT PrepCom May 2009. http://www.vertic.org/assets/Events/090509%20UK-Norway%20Initiative%20Presentation.pdf

[22] Technical Approaches and Information Security, AD Dougan, Lawrence Livermore National Laboratory. http://www.carnegieendowment.org/static/npp/pdf/20090409-dougan.pdf

[23] CTBT radionuclide verification and the British laboratory, C Comley and O Price, Verification Yearbook 2003 http://www.vertic.org/assets/YB03/VY03_Comley.pdf

2010 was $2.1 billion.[24] There is also scope for greater US-UK collaboration in this area. This could be an alternative to enhanced collaboration on the design of new warheads.

8. Conclusion

Key issues for AWE include the relationship with the US, the need for surety, what level of damage the nuclear arsenal is designed to inflict, and whether warhead modernisation is required to retain expertise. Steps that could be taken to radically alter AWE include de-alerting, de-mating, dismantling nuclear weapons, a virtual nuclear, and finally the active elimination of nuclear expertise. The facilities and expertise required for a virtual arsenal would be reduced if the potential was restricted to air-dropped fission weapons. The skills used at AWE are not unique and could be used to benefit other projects. A reduction in AWE's design and production work could be offset by expanding the verification and non-proliferation programme.

[24] FY2010 Congressional Budget Request National Nuclear Security Administration, Department of Energy. http://www.cfo.doe.gov/budget/10budget/Content/Volumes/Volume1.pdf