

# The United Kingdom's Defence Nuclear Weapons Programme

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## 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

### I - Introduction

1. In the Strategic Defence Review the Government set out clearly its commitment to the goal of the global elimination of nuclear weapons, and that when it is satisfied with verifiable progress towards this goal it would ensure that the United Kingdom's nuclear weapons would be included in multilateral negotiations.
2. Effective verification is critical to the sustained success of any arms control or non-proliferation agreement. It is a field where the United Kingdom has always sought to make a substantive contribution to the negotiations and implementation of international arrangements. Effective verification is particularly important in any arrangements involving nuclear weapons. Their immense destructive power means that the consequences of any State successfully cheating on its nuclear obligations are potentially much greater than with other weapons. Consequently, any nuclear arms control verification arrangements will need to provide a very high degree of confidence that all States are complying with their obligations.
3. The Government is aware of work being undertaken elsewhere on the verification of nuclear reductions and the elimination of nuclear weapons, particularly in the United States national laboratories, and through the US/Russia/IAEA Trilateral Initiative on verifying the disposition of surplus US and Russian fissile material. The Government has also noted that the United States and Russia have undertaken in the context of negotiations on a START III Treaty to consider measures relating to the transparency of strategic nuclear warhead inventories and the destruction of strategic nuclear warheads and any other jointly agreed technical and organisational measures to promote the irreversibility of deep reductions including prevention of a rapid increase in the number of warheads. The United Kingdom is not currently party to any of these programmes or initiatives. However, although the obligations of Article I of the Nuclear Non-Proliferation Treaty will inevitably impose some constraints on nuclear weapon verification work with non-nuclear-weapon States, verification of nuclear reductions and nuclear elimination is clearly an area where all States have an interest in developing further both national and international capabilities as part of the process of nuclear disarmament.
4. Verification of nuclear reductions and the global elimination of nuclear weapons will clearly involve a wide range of complementary capabilities and arrangements. The Strategic Defence Review particularly considered the United Kingdom's capabilities with a view to ensuring that when the time came to include the United Kingdom's nuclear weapons in multilateral negotiations, we will have a significant national capability to contribute to the verification process. In particular it considered the United Kingdom's capabilities in three main areas:

- The ability to verify that States are not testing nuclear weapons or other nuclear explosive devices;
- The ability to verify that States are not producing fissile material for nuclear weapons or other nuclear explosive devices; and
- The ability to verify reductions and dismantlement of nuclear weapons in any State that might have produced or otherwise acquired them.

5. The Strategic Defence Review concluded that the United Kingdom has developed particular expertise in the monitoring of nuclear tests, primarily at the Atomic Weapons Establishment. We have also developed particular expertise in the management and monitoring of fissile material, especially through the involvement of the Department of Trade and Industry's Safeguards Office and the United Kingdom's civil nuclear industry in the International Atomic Energy Agency's and EURATOM's safeguards systems. The Government intends to maintain these strengths. The first is important in globally implementing the Comprehensive Nuclear Test Ban Treaty and maintaining a national capability to assess the information provided by the Treaty's verification system. The second is fundamental to implementation of the Nuclear Non-Proliferation Treaty, will be central to negotiation and implementation of a Fissile Material Cut-Off Treaty and will also, over time, have an important role to play in any future international oversight of reductions in the military stockpiles of fissile materials held outside existing international safeguards arrangements.

6. The Strategic Defence Review also concluded that the United Kingdom had only a very limited capability to verify the reduction and elimination of nuclear weapons. The Government therefore set in hand a programme to develop expertise in this area, drawing in particular on the skills of specialists at the Atomic Weapons Establishment. Since the autumn of 1998 a small team has been considering the technologies, skills and techniques that might be required. As set out in the SDR, this work has deliberately focused on identifying the capabilities potentially available in the United Kingdom, in order to ensure that before engaging in wider consultation on this subject we established a clear national baseline. The team has now reported and a full copy of their report, *Confidence, Security and Verification: The Challenge of Nuclear Weapons Global Arms Control*, has been published by AWE Aldermaston. Copies can be found on the AWE website at [www.awe.co.uk](http://www.awe.co.uk), and on the Ministry of Defence website at [www.mod.uk](http://www.mod.uk). A summary of the report and plans for future work in this area are set out below.

## **II - Verification of Nuclear Reductions and Elimination**

7. The nature of verification arrangements is highly dependent on the terms and nature of the agreement they are seeking to verify. Existing nuclear arms reduction treaties, such as START I and II, to which the United Kingdom is not party, have concentrated primarily on verifying the deployment and elimination of delivery systems rather than warheads. However, given the limited size and composition of the United Kingdom's minimum nuclear deterrent, any multilateral nuclear reduction agreement to which the United Kingdom might be party is very likely to need to deal directly with verification of nuclear warhead numbers, and in time of their destruction.

8. Highly intrusive verification will be less critical to the success of nuclear reduction agreements while all parties continue to possess significant numbers of weapons as protection against potential non-compliance by others. But as stockpiles reduce towards very small numbers and confidence in full

compliance becomes more essential, verification requirements are likely to become increasingly onerous. In particular intrusive physical access to facilities and greater transparency of design information will become increasingly important. National Technical Means to detect undeclared facilities and materials will also be important. The eventual achievement of the global elimination of nuclear weapons will require the development of extremely rigorous verification arrangements in order to provide the very high level of confidence and assurance that will be necessary. In particular, assurance would be needed that a warhead had entered the verification regime, and an unbroken chain of custody of materials would thereafter need to be maintained to ensure that no subsequent substitution of materials could take place without being discovered. However, no conceivable verification regime is likely to be able to provide an absolute guarantee of full compliance. Political acceptance of some level of risk, albeit the minimum possible, will almost certainly be necessary.

9. In examining these issues the AWE study identified three key technical areas that will provide the focus for its further work on verification:

- **Authentication** of warheads and their components. Deciding, with the assistance of appropriate technology, that an article is what it is declared to be, will be a critical aspect of any treaty;
- **Dismantlement**, which examines the issues that may arise following withdrawal of nuclear weapons from the stockpile under arms control arrangements and the need to establish a satisfactory chain of custody of fissile materials and other components through to an agreed final disposition state; and
- **Monitoring the Nuclear Weapon Complex** to provide background information on the technologies, skills and techniques that may be used to establish the existence and/or the status of nuclear weapons programmes and thereby provide corroborating evidence useful in monitoring nuclear weapon stockpiles, and particularly in the event of challenge inspection.

A summary of the report's discussion of and preliminary conclusions on the issues involved in these areas is set out below.

## **Warhead Authentication**

10. Authentication of warheads will be at the centre of any nuclear reduction and elimination verification arrangements. Authenticating a warhead and then maintaining an appropriate chain of custody through to its dismantlement and ultimate disposition of the material it contains will be one of the most technically challenging verification issues that will need to be resolved.

11. Non-destructive assay and evaluation techniques will have a considerable contribution to make in:

- verifying the existence and number of treaty declared warheads, including those operationally deployed;
- providing vital information about nuclear materials much more quickly, cheaply and more safely than chemical or other analysis of samples taken; and
- through use of information barriers, allowing verification without compromising national security and/or proliferation sensitive design information that national legislation and

international obligations may require to be kept secret from international inspectors.

12. A range of active and passive radiation monitoring techniques already exist and are applied daily in AWE and in the civil nuclear industry. Passive techniques can provide quantitative information on the material inside a warhead case, but rely on the warhead emitting enough radiation to be measured. Active techniques do not lend themselves so well to quantitative measurement, but can be used to assay warheads or warhead components that do not emit sufficient radiation for passive detection.

13. The study conducted a national survey which identified existing areas of technical competence in the United Kingdom. Further work will be done to explore how to draw cooperatively on this expertise. The study focused on the potential use of various radiation signature types and combinations in verification, rather than on identification of specific detector technologies. However, new detector technologies will be evaluated for their potential to contribute to verification. Further work will also be done on evaluating the potential contribution of other non-destructive evaluation techniques, such as acoustic resonance spectroscopy, that are not based on detection of radiation.

14. Work so far has addressed whether a warhead or component authentication regime can determine that the item presented for identification is an authentic nuclear warhead and not a hoax using non-destructive detection and measurement systems alone. If this is not possible then effective complementary verification arrangements to establish a clear chain of custody that can track the movement of declared warheads will need to begin early enough in the warhead cycle to provide a very high level of confidence that the items presented are indeed bona fide nuclear weapons.

15. A fundamental issue that any verification arrangements will need to address is how to provide viable verification without compromising national security and proliferation sensitive design information. Any measurement will provide some degree of design information (for example on fissile material composition and quantities), and authentication will require access to a range of information in order to make a credible assessment. The study therefore considered whether data protection arrangements might be possible that would permit such information to be determined and used in the verification process without making it directly available to the inspector conducting the verification. It concluded that it may be possible to use a suitable computer to acquire, analyse and use high-resolution data without the possibility of inadvertent disclosure, but that a range of issues would need to be resolved on how to confirm that information used for comparison was itself accurate and relevant without compromising the information in the process.

16. The study team examined the potential capability of individual and combined non-destructive techniques against a range of generic nuclear warhead designs in order to assess the level of information they would provide. Essentially, more information could be determined about plutonium-based devices than about ones containing high enriched uranium, and about single as opposed to two-stage devices. Considerable further work is needed here, but the preliminary conclusion was that without considerably greater transparency about specific warhead design information it is not possible to authenticate an item as being a nuclear warhead, or not, by non-destructive radiometric assessment alone. Such assessment would however provide useful information as part of a broader-based authentication approach also drawing on other verification techniques and administrative information. Maintaining a clear chain of custody of individual items subject to verification under any agreement is likely to be particularly important.

## **Dismantlement and Disposition**

17. Following authentication of a nuclear warhead, it will be important to be able to follow the progress of the weapon through the remaining stages of the life cycle from withdrawal from the stockpile, through dismantlement of the warhead, to final disposition of the fissile material it contains. This dismantlement and disposition process is likely to have several stages, including separation of the warhead from its delivery vehicle, separation of the high explosive from the fissile material within the warhead, and demilitarisation of the fissile material components to require remanufacture before they could be reused.

18. Each of these stages will pose their own verification challenges, and the number and type of authentication measurements required will be directly related to the transparency of, and access of inspectors to monitor, dismantlement activities. The less visible the process is to inspectors, the more authentication measurement will be needed. The crux of preserving confidence in verification arrangements will be to maintain a credible chain of custody. This will be complicated if, as seems likely, there will be only limited access for direct inspection of key components. This is not, however, a unique problem. It applies also to much of the civil fuel cycle. There is no reason why similar tracking arrangements to those used in the civil nuclear programme could not also be adapted in the nuclear weapon dismantlement process. Further research will be required on this, in particular to investigate the implications of any requirement to protect information about the mass and isotopic content of military fissile material.

19. The study considered the potential contribution of a range of non-destructive assessment techniques to verification of the dismantlement process, including gamma-ray spectrometry, neutron measurements, and environmental monitoring. Further work is required on all of these, and the technologies available. In particular, it is intended to use the current Chevaline warhead disassembly programme to assess the potential value of environmental monitoring data. The study concluded that if all these techniques can be applied to tracking nuclear warheads through the dismantlement process, it should be possible to achieve a high degree of verification confidence.

20. Further technical studies have been identified to investigate the value of nuclear and non-nuclear based non-destructive assaying, and other measurement strategies. These studies will also investigate techniques for maintenance of the chain of custody, including evaluation of the applicability of tagging and sealing technologies used in existing international verification regimes.

21. Maintaining surveillance of discrete items subject to verification can also be complemented by arrangements to maintain surveillance of dismantlement facilities themselves using a combination of fixed and mobile monitors. These could include radiation sensors as well as other complementary techniques such as CCTV, time-lapse photography, movement sensors, and tamper-indicating devices and seals. A number of such systems are currently in use, for example in the IAEA safeguards regime, and future work will ensure that this knowledge and experience is assessed and applied to work on verification. The study also concluded that the surveillance process would benefit from effective controls on the number and movements of items subject to verification into, around and out of the dismantlement facility.

22. The study considered briefly the requirement for verification of the disablement of nuclear warhead components, disposition of fissile material, and limitations on States' nuclear weapons industrial infrastructure. The United Kingdom has operational experience of disablement technologies that can serve as a starting point for further work on these. There has already been very considerable national and international work on fissile material disposition that needs to be taken into account in any future work. Further studies are planned to improve our understanding of the issues related to

control and eventual dismantlement of nuclear weapon infrastructure. This will draw both on UNSCOM experience in dismantling Iraq's nuclear facilities and the expertise of those groups and agencies involved in decommissioning nuclear facilities in the United Kingdom. In the first instance, further work will take place on the practicalities and implications associated with verifiably maintaining, reducing and dismantling a nuclear warhead production infrastructure, and on consideration of what might reasonably constitute a minimum nuclear warhead infrastructure.

### **Monitoring the Nuclear Weapon Complex**

23. There are a range of existing and emerging technologies, skills and techniques that can be used to establish the existence and/or the status of a nuclear warhead infrastructure complex and its operations. Some of these techniques may also have a role in authentication and verification of the chain of custody. Knowledge and understanding of the infrastructure will be critical to any verification regime, and some degree of transparency about this will be essential, within the limits imposed by national security and non-proliferation obligations.

24. Environmental monitoring technologies may, depending on the circumstances, have a role in arms reduction verification, including by provision of continuous monitoring around sites, during on-site inspections, to locate covert plants involved in the nuclear weapons cycle, and to provide supplementary data as part of the dismantlement verification process. Potential applications, which need further investigation, include possible techniques for sample collection both on site and over a wide area, for real time in-field monitoring both on-site and wide area, laboratory analysis of samples, and the management and interpretation of the integrated information gathered from all sources. However, such techniques will need to be considered carefully to ensure that their use does not compromise proliferation-sensitive design or weapons technology information.

25. The United Kingdom already has a range of expertise in this area, both within AWE and in the broader scientific community. Further work is being set in hand to consider its implications for facility monitoring and to establish baseline information, including consideration of the applicability of existing International Atomic Energy Agency environmental monitoring arrangements.

### **Further Work**

26. The study has identified an extensive list of further technical and systems studies to research verification issues arising from the reduction and elimination of nuclear warheads, some of which have been referred to above. In order to manage this programme effectively AWE is establishing a Verification Research Programme within a broader new Threat Reduction mission integrating a range of complementary existing AWE activities. This research programme will have three prime foci:

- Arms control/reduction verification technical research;
- Arms control/reduction verification studies; and
- Continuing existing work on verification of nuclear testing.

The programme will seek to draw on and develop external links with other relevant areas in the Ministry of Defence and other Government Departments, as well as with academia, industry and non-Government Organisations.

27. Five theme areas for further studies have been identified: stockpile status; authentication; dismantlement; disposition; and systems performance. Across these areas three specific projects have been identified for the next year, some of which will carry on into future years:

- The ASSERT Project (Authentication of Stockpile Signature Evidence by Radiometric Technologies.) This will form the focus for studies associated with warhead and component signature authentication and chain of custody tracking. In addition to reviewing the suitability of appropriate technologies, the Chevaline dismantlement programme will be monitored to gather real-time data. This will allow the difficulties of verification to be assessed in a realistic and controlled manner. A companion study will be carried out on Trident in later years.
- The EMERGE Project (Environmental Monitoring Evidence from Regional and Global Emissions.). This will be the focus for studies into environmental monitoring techniques on the weapons complex rather than the warhead.
- The RENEW Project (Recovery of Nuclear Evidence on Warheads.) This will investigate the issues associated with the historical recovery and future generation of documentary evidence to support transparency and confidence building measures.

### **III - Conclusion**

28. The Government welcomes and supports the general conclusions of the AWE report. It hopes that the report will help to develop a deeper understanding of the difficulty and complexity of the issues involved in verifying the reduction and eventual elimination of nuclear weapons. With a view to addressing these issues the Government intends to pursue the further development both of the United Kingdom's understanding of the issues involved, and of our technical capabilities. The continuing programme of work AWE have identified will contribute directly towards this. This programme will continue to be funded by the Ministry of Defence.

29. Further work on nuclear verification at the Atomic Weapons Establishment will clearly need to draw on external expertise and take into account related developments elsewhere in the United Kingdom and overseas. The Government therefore welcomes and endorses AWE's intention to seek to develop its external links where possible, both within the Government and with the academic and expert non-Governmental communities. As work proceeds the Government will also wish to consider the scope for encouraging and developing broader bilateral and international cooperation on this subject.