Eliminating the Threat

of

Weapons of Mass Destruction

Report of a symposium organized within the programme of the
British Association Science Festival at the University of Exeter
in September 2004

British Pugwash Group

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Preface

by

Robert Hinde CBE FRS FBA

The symposium at the British Association on which these papers are based was organized by Sebastian (Bas) Pease. Bas wrote the Foreword a few days before he died on October 17th 2004. With his death following a short but acute illness, the world lost a distinguished scientist and a remarkable man.

After carrying out some important applied work during and just after World War 2, he started to work on nuclear fusion in 1955, when he became leader of the Physics Research Team at Harwell. The British fusion programme was transferred to Culham, where he became Division head and later, in 1967, Director of the Culham Laboratory. He was successful in establishing collaboration with Russian fusion experts, and was later instrumental in having the Joint European Torus project established at Culham. He was a Fellow, and later Vice-President, of the Royal Society, and served as President of the Institute of Physics. He received the Glazebrook Medal in 1989.

In the nuclear debate Bas was a crossbencher – a strong advocate for the use of nuclear power, but equally opposed to the use of nuclear weapons. He was a prominent member of British Pugwash, and in 1995 he was Chairman of the British Pugwash Group and a member of the International Council when the Nobel Peace Prize was awarded jointly to the Pugwash organisation and its then President, Joseph Rotblat. His contributions to the discussions in the British Pugwash Group are greatly missed.

Eliminating the Threat of Weapons of Mass Destruction

FOREWORD

by

Sebastian Pease FRS

This booklet is based on three talks given at the British Association Festival of Science, September 2004 at Exeter University in a session optimistically entitled 'Eliminating Weapons of Mass Destruction'. The authors are most distinguished in their fields of expertise and we are very grateful to them for this opportunity to give their views a wider audience.

The original title was optimistic because, in truth, these dreadful weapons – biological, chemical and nuclear, can not be disinvented. Governments – who are the only real deployers of WMD – can always rebuild a stock, unless restrained by international agreement, inspectorates and enforcement agencies. It is to these latter that we must look for peace of mind, if mankind is to survive without suffering the use of WMD against one and another.

In many ways the Chemical Weapons Conventions is the most advanced. It is a scandal that the USA blocked the compliance protocol that would have strengthened the Biological Weapons Convention of 1972. Worse still is the continual actual deployment of nuclear weapons permitted by the Nuclear Non-Proliferation Treaty 1970 to five nuclear weapons powers. The UK plays an unforgivable role here – deploying a nuclear submarine armed with 16 missiles nuclear tipped with warheads each five times more powerful than those which destroyed Hiroshima and Nagasaki. The American deployment is even more grotesque: at the last count *fourteen* nuclear submarines armed with nuclear war-headed missiles were at sea, ready to destroy the cities and civilisations of supposed (and real!) enemies. It is true that under the same treaty the five nuclear weapon states are committed to eliminating their nuclear weapons, but precious little is done, chiefly by the widespread use of the principle of unripe time. No wonder that non-signatories to the NPT continue to use nuclear weapons!

I hope this booklet will arouse attention once again to these dangers, and the need to establish adequate international measures which will successfully eliminate the threat of WMD being used.

Nuclear Weapons

Christopher Watson

A priority for our generation

The expression 'weapons of mass destruction' has become a political cliché, the true meaning of which has become lost through over-repetition. For better or worse, many of those living in the 21st century have no vivid impression of the reality behind the words. To those who lived through the Second World War however, the nuclear weapon strikes at Hiroshima and Nagasaki were not just two more events in a horrible war – they were devastating events on an unprecedented scale, with death tolls of about 140,000 and 70,000 respectively[1]. They also led to some 350,000 injured requiring treatment, and left two cities as charred heaps of rubble extending over several square miles each. These weapons did indeed cause mass destruction.

Although nuclear weapons are the clearest, and most destructive example, there are other weapons which have come into prominence in the 20th century which have a comparable potential for destruction of human life on a massive scale. Chemical weapons, which came into large-scale use in the First World War, caused a death toll of a similar magnitude, if not quite so instantaneously – about 100,000 died in that war through the use of the comparatively un-sophisticated chemical weapons of that time[2]. Much more lethal chemical weapons have been developed since then, and such weapons have continued to be used up to quite recent times, and (for example) caused some 4000 deaths during Saddam Hussein's attack on Halabja (Iraq) in 1988. Biological weapons, though mercifully not yet used on a comparable scale, have the potential to cause equally enormous loss of life.

In the 21st century, we are sometimes inclined to think that mankind has learned from these past horrors – that there is a powerful taboo against the use of such weapons, and that this has been embodied in a range of international agreements to ensure that such things cannot happen again. Sadly, this is only partly true. There is a nuclear taboo, but it is fragile. It has survived because the majority of nuclear-weapon-owning states have chosen that it should. However there are a number of non-signatories of the Non-Proliferation Treaty (NPT), and some rogue sub-national groups, which seem willing to threaten to cause massive nuclear damage, and some of these (e.g. in the India-Pakistan confrontation) have come perilously close to doing so in the past few years. The existing chemical taboo is even more fragile, and (as the example of Iraq shows) leaders of some nation states have chosen to ignore it.

This paper starts from the assumption that our generation is responsible for tackling the problem of weapons of mass destruction. Our successors will rightly judge us harshly if we close our eyes to them and hope that they will go away, only to discover that states or sub-national groups have chosen to develop and use these weapons to advance their causes. The good news is that there are a number of current international initiatives, including some on a very large scale, which are addressing these problems, and this paper will summarise these, and highlight their achievements and prospects. However, there are many issues which these initiatives do not address, and this paper will also draw attention to one of these – the ongoing invocation of 'Independent Nuclear Deterrence' by Britain – where our military stance is in stark contrast with our enthusiasm for international disarmament.

The specific problem of nuclear weapons

This paper is concerned with the specific problem of nuclear weapons – chemical and biological weapons being discussed in the two following papers. The current situation is

dominated by the legacy of the Cold War, which led to the production and deployment of enormous arsenals of nuclear weapons in the name of 'deterrence'. Although the numbers have declined somewhat since their peak in the 1980s, they are still extremely large. According to the SIPRI yearbook for 2003[3], the world nuclear forces, by number of deployed warheads, currently stands at:

Table 1. World nuclear forces by number of deployed warheads, SIPRI yearbook 2003

Country	Strategic warheads	Non-strategic warheads	Total warheads
Russia	4852	3380	8232
USA	5948	1120	7068
China	282	120	402
France	348	—	348
UK	185	—	185
Israel	—	—	(200)
India	—	—	(30-40)
Pakistan	—	—	(30-50)
Total			c. 16,500

The total yield of this world-wide inventory is about 3000 megatonnes equivalent.

In addition to this list, it is important not to forget the potential for other countries to develop and deploy nuclear weapons. Two 'threshold nuclear' countries of particular concern at present are Iran and North Korea, both of which have the potential to create (or may indeed have already created) their own nuclear weapons.

Several comments can be made on this table. At a first glance, it may seem reassuring that the overall total is overwhelmingly a legacy of the Cold War – only a minute fraction of the total inventory was created with any other conflict in mind. Furthermore the overwhelming majority of the weapons are now in the possession of stable democracies, which have signed the Non-Proliferation Treaty and are (arguably) both unlikely to use them, and competent in their management (making theft unlikely). However, the mere number of warheads is not by itself a good measure of the likelihood that they will actually be used; and if the numbers are then weighted to include some assessment (inevitably rather subjective) of the probability that each warhead will be used, then a rather different (and less reassuring) picture emerges, with the inventories of Israel, India and Pakistan (and indeed the potential inventories of Iran and North Korea) becoming much more significant.

International measures to control or reduce nuclear weapons

There is no doubt that since the dark days of the Cold War, there have been a number of changes for the better.

1. There are now a number of valuable international treaties in this area:
   - The Non-Proliferation Treaty (NPT 1968)
   - The 1963, 1974 and 1996 Test Ban Treaties
   - The Outer Space Treaty (1967)
   - The ABM Treaty (1972 defunct 2002)
   - The Intermediate Range Nuclear Forces Treaty (1987)
   - START I (1991) and START II (1993 defunct 2002)
   - Strategic Offensive Reduction Treaty (2002)

These treaties have collectively made a large contribution to reducing the likelihood of a nuclear war today, as compared with the situation in 1960. But these treaties are incomplete and fragile, especially under current US government policy. They fail to tackle problems

such as non-signatories, mendacious signatories, and sub-national groups which may become capable of developing nuclear weapons or 'dirty' bombs.

2. The Russian component of the problem is currently being tackled in some valuable ongoing international initiatives, which will be discussed below.

3. A number of countries with civil nuclear industries (e.g. Canada and Japan) have explicitly chosen not to embark on nuclear weapons manufacture. Other countries have stopped doing so and dismantled their weapons and facilities (South Africa and Libya are examples).

However, a number of countries in the SIPRI league table are continuing to include nuclear weapons in their military posture (either explicitly or tacitly). They should all be considering their position. Since good practice begins at home, we in the UK should be asking ourselves some important questions about our own nuclear weapons policy, and we will return to this later.

International initiatives aimed at reducing Russian WMD

As the SIPRI data in Table1 show, Russia has (marginally) the largest number of nuclear weapons. There are now a number of international initiatives to help Russia to manage, and progressively reduce, its nuclear legacy.

Table 2. Cooperative threat reduction programme for Russia

Category	Baseline	2003 Reductions	Current Cumulative Reductions	2007 Target for Reductions	2012 Target for Reductions
Warheads Deactivated	13,300	182	6252	8564	9444
ICBMs Destroyed	1473	36	527	821	1131
ICBM Silos Eliminated	831	13	455	485	485
ICBM Mobile Lauchers Destroyed	442	5	8	174	381
Bombers Eliminated	207	24	124	129	138
Nuclear ASMs Destroyed	708	141	668	708	708
SLBM Launchers Eliminated	728	12	408	520	628
SLBMs Eliminated	936	92	460	629	712
SSBNs Destroyed	48	3	27	35	40
Nuclear Test Tunnels/Holes Sealed	194	0	194	194	194

1. The US Cooperative Threat Reduction (CTR) Programme[4]

Following the collapse of the Soviet Union in the early 1990s, its arsenal of weapons of mass destruction was left in an uncertain state. Concern about this prompted the US Congress to pass the 'Nunn-Lugar' Soviet Nuclear Threat Reduction Act of 1991, following which, in the mid 1990s, the US Department of Defense established the Cooperative Threat Reduction (CTR) programme office under the Defence Threat Reduction Agency (DTRA), responsible for managing and implementing a major programme to assist the Commonwealth of Independent States (the CIS countries) in the management and reduction of its nuclear legacy, with a budget which has by now reached some $4.4 billion.

Under this programme, by 2003 Kazakhstan, Belarus and Ukraine had eliminated all of their intercontinental ballistic missiles, missile silos, and heavy bombers, in line with their START commitments. However the most ambitious part of the CTR programme is in Russia itself, where the status as at December 2003[5] is shown in Table 2 opposite. By any standards, the CTR programme has been an extremely successful example of nuclear disarmament in action. It has, of course, been matched by a comparable programme of weapon reduction within the US itself.

2. The Kananaskis G8 Global Partnership Initiative (GPI)

This agreement, also known as the '10+10 over 10' agreement (since it was envisaged as being funded by $10 billion from the USA and $10 billion from other G8 countries over a period of 10 years), was signed at the G8 summit at Kananaskis in July 2002, following an initiative of the US government, made in the aftermath of the 9/11 disaster. Its objective is to provide funds to the former Soviet Union (FSU) countries to help ensure that sensitive nuclear and chemical materials cannot fall into the hands of terrorist groups, and in particular to assist those countries in the destruction of chemical weapons, the dismantling of decommissioned nuclear submarines and the re-employment of former weapons scientists.

Commitments or indications from G8 countries (as at June 2003) are[6]:

- United States plans to disburse $10 billion
- Russia $2 billion
- Britain $0.75 billion
- Canada $0.65 billion
- Japan will allocate €0.2 billion
- Germany €1.5 billion
- Italy €1 billion
- France €0.75 billion
- European Union €1 billion

The total to date is *c.* $17.85 billion.

The G8 GPI programme can be regarded as an umbrella under which a number of other international programmes and agencies operate. These include:

3. *The IAEA Contact Expert Group (CEG)*
4. *The Northern Dimension Environmental Partnership (NDEP)*
5. *The Multinational Nuclear Environmental Programme in Russia (MNEPR)*
6. *The Arctic Military Environmental programme (AMEC)*
7. *The EU Tacis programme*
8. *Bilateral aid programmes in Russia funded by countries such as Canada, Finland, France, Germany, Japan, Norway, Sweden, the UK and the USA*

It has to be said (and the Russian government does not shrink from saying) that progress in turning the G8 commitments into funded programmes has so far been painfully slow.

Nevertheless a few participating countries have made a good start, and in October 2004, the values of signed contracts stood at ($M):

US	72
Germany	40
UK	30
Norway	22
Canada	19

The UK is seen to be in a relatively strong position in the implementation of its GPI commitment: this work is under the coordination of the Department of Trade and Industry, and is managed on its behalf by RWE Nukem, BNFL, PE International and AEA Technology.

The British contribution to the GPI programme

The principal elements of the current UK programme are[7]:

- General purpose nuclear submarine decommissioning (initially two Oscar-1 submarines)
- Spent Nuclear Fuel management at Andreeva Bay (a naval base in NW Russia)
- Spent Nuclear Fuel storage at Atomflot, Murmansk
- The Closed Nuclear Cities Partnership (helping former weapon scientists to shift to civilian commercial life)
- Collaboration with the US and Norway on transportation and storage of decommissioned submarines
- Collaboration with EU Northern Dimension Environmental Partnership (on nuclear environmental projects)

The following sections give further detail on some of these elements.

1. Nuclear submarine decommissioning

The Russian nuclear submarine fleet, constructed during the Cold War years, consisted of some 250 nuclear submarines. Of these, some 90 were 'strategic' submarines with ballistic nuclear missiles (SSBNs), 60 had guided missiles (SSGNs), 90 were General Purpose and 10 were of a special design using liquid-metal-cooled reactors. These submarines are all large vessels, weighing 10,000-35,000 tonnes, and most of them have two pressurised water reactors of ~100 MW(th) each. A typical submarine has about 450 Spent Fuel Assemblies (SFA) on board, which contain over 90% of its radioactive inventory. About 190 of these submarines have now been withdrawn from service: however, most of these are still afloat and have their SNF still loaded.

Submarine decommissioning is a complex six-stage process

- Removing the weapons and highly-classified systems
- Removing the strategic missile tubes
- Defuelling and Spent Nuclear Fuel (SNF) management
- Separating the active and inactive parts of the submarine:
- Recycling materials from the inactive part
- Management of the radioactive wastes

President Putin signed a decree in February 2000 establishing a programme to complete the decommissioning of the withdrawn submarines by 2010, which depends on international support. International agreements relating to the elimination of these submarine-based weapon systems have had a long and chequered history. The US CTR programme led the way, with a focus exclusively on the 'strategic' (SSBN) submarines. More recently, it has been followed by a number of bilateral aid programmes (Canada, Norway, Sweden, Japan, UK) which are assisting with the remainder of the fleet. All of these activities have now been subsumed under the Global Partnership Initiative.

A number of factors have affected the rate of decommissioning, which is now running at about 20 submarines per annum. Historically, the main problem has been lack of funding: however this has now been aggravated by technical bottlenecks and regulatory problems (since all nuclear activities in Russia have to comply with their national regulatory procedures), and the various international programmes are having to tackle these. The UK has initially funded the dismantling of two Oscar submarines, which has helped the shipyard (Zvezdochka) to upgrade its dismantling facility, and is tackling some of the bottlenecks.

2. The Cold War legacy at Russian Naval Bases

There are about 20 major naval bases for submarines in NW and FE (Far Eastern) Russia, all notionally still in service. Of these, about eight are currently primarily devoted to the submarine decommissioning programme. All 20 have large amounts of radioactive material

(including in several cases highly-enriched nuclear fuel) which could be of interest to a terrorist. Furthermore, during the Cold War, the priority was to keep the nuclear fleet in service, and this led to radioactive waste management practices at the naval bases which a later generation have come to regret. There is now major ecological damage at many of the naval bases, particularly at the Andreeva, Gremikha and Sysoyeva bases where Spent Nuclear Fuel was handled, though at all of them there are significant stores of radioactive waste, and in most cases the wastes are un-conditioned and deteriorating. There are also about 30 nuclear service ships which were used to handle and store Radioactive Waste and SNF, of which the best known are *Lepse*, *Lotta*, and *Imandra*, all elderly, and awaiting remediation/disposal. The UK programme is concentrated at Andreeva Bay, which has the largest single accumulation of SNF, and where the ecological problems are particularly severe.

3. Spent Nuclear Fuel (SNF) management

SNF management is one of the key bottlenecks in the submarine decommissioning programme, because of the limited defuelling capacity, the insufficient capacity of the only SNF reprocessing plant, Mayak, and the insufficient interim storage capacity.

Over a 10-year period, the programme will have to handle:

- 43,000 SFA (Spent Fuel Assemblies) already in store on dry land
- 82,000 SFA being removed from withdrawn submarines

The existing storage capacity is almost exhausted, and is well below modern standards.

The capacity of the Mayak SNF reprocessing plant is too low to solve this problem (its maximum throughput is about 7000 SFA p.a.). There is therefore an urgent need for interim storage. The options for solving this problem are vault or cask stores. Rosatom (the Russian State Agency responsible) currently prefers the cask option, and the UK is assisting in the creation of interim cask stores at Murmansk and is exploring the options for Andreeva Bay.

4. The Closed Nuclear Cities Partnership

During the Cold War years, Russia built 10 Closed Nuclear Cities, in which the work of constructing its nuclear weapons and associated rocketry was carried out. Their combined population amounts to some 700,000 inhabitants – weapons scientists and their families and support infrastructure. They have now largely lost their historic mission, and need help to change direction. The West, recognising that it is in its interests to ensure that these scientists are not tempted to offer their services to threshold nuclear states, has been trying to help since 1992, through a series of international programmes:

- The ISTC programme, aimed at providing opportunities for individuals at the Institutes in these cities to diversify into non-military activities;
- The US Nuclear Cities Initiative has sought to bring about change by creating commercial production facilities;
- The UK Closed Nuclear Cities Partnership, launched in 2002, is aiming specifically at the creation of sustainable jobs.

The first of these programmes had rather limited success, since scientific projects at Institutes did not automatically lead to any sustainable civilian activity. The second also had rather mixed success: it tried to create viable commercial activities, but encountered a number of difficulties in the relationship of the US and Russian bureaucracies. The current UK programme is very specifically aimed at starting up commercial activities which will bring sustainable new jobs, using the skills which the individual scientists possess. It is currently funding technology and business development activities in five such cities – Sarov, Seversk, Snezhinsk, Zheleznogorsk and Ozersk.

In summary, there is now a very substantial international programme under way, in which the UK is playing a leading part, which will within a decade have contributed to the elimination of a substantial part of the Russian nuclear weapons inventory, their associated means of delivery, and the nuclear materials which might be used by a terrorist.

We now turn from Russia to another country, which is rather lower in the SIPRI nuclear weapon league table, but nevertheless has an objectively very large inventory of nuclear weapons – Britain.

A key issue for Britain – the future of our 'nuclear deterrent'

Introduction

During the past 57 years the UK has developed some 9 different nuclear weapons[8], starting with the Blue Danube, a free-fall bomb which was first taken into service in 1953, and culminating with the Trident II missile warhead, which was brought into service in 1992, and which constitutes the core of the current UK 'independent nuclear deterrent'.

There has not been a published study of the cost of this UK programme, comparable to the magisterial Brookings Institute study for the US programme[9], and some of the cost information remains classified, but the following figures are in the public domain:

Cost of nuclear weapons R&D1945-52, including first test at Monte Bello[10] £150M
Expenditure on nuclear weapons 1963-1980[11] £2.7 billion
Average annual cost for Polaris from 1981 to 1991[12] £400 million
Total cost of acquiring the Trident system 1980-1994[13] £12.5 billion.

These figures alone, uplifted to 2004 prices, total £48.5 billion, and there are some evident gaps in the information, so it is unlikely that the total cost has been less than £50 billion. This figure is consistent with an average expenditure of £1 billion p.a. throughout the past 50 years. The ongoing maintenance of the Trident capability now costs about £1.5 billion per year. It has also been estimated that the cost of decommissioning all the facilities involved (including the 26 nuclear-powered submarines and the various weapon development and production facilities) would be a further £32 billion[14].

Should Britain maintain this policy indefinitely?

It is not self-evident that Britain should continue its policy of maintaining an 'independent nuclear deterrent' indefinitely. At various points during the history of this policy, there have been vocal political groups in Britain (such as CND in the 1960s) which have argued for a policy of unilateral disarmament. However in recent years this issue has ceased to be of central public concern. This situation may however shortly be about to change, and the issue may once more become centre-stage. This is because the Trident system, which came into service 12 years ago, has a design lifetime of about 30 years, and the timescale for the development of a complete successor system might be as much as 10 years. So it is understandable that the MoD should have announced[15] that a decision on whether to replace Trident at the end of its lifetime probably needs to be taken during the current Parliament. It is therefore timely to start a public debate on the issue. In the following sections we provide material which could serve as background for that debate. Two important inputs to this debate, upon which this paper draws, have been publications by the British Pugwash Group[16,17].

The UK nuclear capability in perspective

The UK's nuclear deterrent consists of four British-built submarines, each capable of carrying up to 16 American Trident D5 missiles. Each missile has a Multiple Independently-targeted Re-entry Vehicle (MIRV) capability – i.e. there can be 3 warheads per missile – so a maximum of 48 warheads can currently be deployed per submarine. The warhead yields are classified, but are thought to be typically about 100 kilotons of TNT (i.e. about five times the

yield of the Hiroshima weapon), though there are some with a lower yield – probably in the region of a few kilotons. The UK has stated that it maintains a stockpile of "fewer than 200 'operationally available' warheads". The actual figure is perhaps about 160-174 warheads ready for deployment plus some spares[18]. Thus the UK inventory is about 1% of the world total, i.e. it is near the bottom end of the league table of recognised nuclear powers, as given by SIPRI and shown in Table 1 (page 5).

Possible missions for the UK nuclear capability

An essential background to any serious debate about the need for such a capability is an analysis of the purposes which the possession of such a capability might serve. In the published literature, four possible roles for the UK nuclear capability have been suggested:

1. Strategic defence of the UK by deterrence of a nuclear-capable adversary

- As a contribution to the overall NATO nuclear deterrent (albeit at a level of about 2.5%)
- To provide an independent deterrent in situations where NATO is deemed unwilling to use its nuclear weapons to defend the interests of the UK – under such circumstances the UK threat that it might use its nuclear weapons could act as a deterrent.

2. Strategic use of nuclear weapons by the UK during war

- In reply to enemy nuclear strikes
- In reply to enemy use of weapons of mass destruction, for which the UK possessed no like-for-like retaliatory capability
- To win a war which it could not win by conventional means.

3. A 'sub-strategic' role

To provide a low-yield strike capability against a country which does not itself possess a nuclear capability – e.g.:

- A demonstrative strike, aimed at a non-critical, possibly uninhabited area
- In a punitive role, where a country has committed a hostile act, despite specific warning that to do so would incur a nuclear strike.

4. A 'tactical' role

To achieve military objectives on the battlefield which might be difficult to achieve in other ways.

- 'Bunker-busting'
- Other roles which might arise in the 'war on terrorism'.

Assessment of the credibility of these missions

In this section we consider how far each of these four missions can be regarded as credible.

1. Strategic defence of the UK by deterrence of a nuclear-capable adversary.

The doctrine of deterrence was at the heart of Cold War military thinking. However the circumstances have now changed substantially:

- The military situation is no longer bipolar
- The two leading nuclear powers are engaged in a constructive (if somewhat intermittent) dialogue about nuclear arms reduction
- A number of new actual or potential nuclear states have appeared on the scene
- Sub-national groups (terrorists etc.) can be imagined to acquire (or claim to have acquired) the capability to deploy a weapon of mass destruction.

In these new circumstances, how credible is the doctrine of deterrence? It is sometimes suggested that in Russia, a moderate leader like Putin might be replaced by an extremist such as Zhirinovsky, and that the West might have to seek to deter a renewed nuclear threat from that quarter, with perhaps a leader even less rational than Krushchev at the helm. But that does not make the case for an *independent* UK capability; to do so, one has to suppose:

- that Russia has a quarrel specifically with the UK;
- that Russia judges that the US would choose not to exercise its responsibilities under the NATO treaty; and
- that the UK would be willing to risk overwhelming Russian nuclear retaliation.

The likelihood of all these contingencies coming together must be very small.

The risk of a nuclear threat from any of the other NPT nuclear weapon states, or from Israel, India or Pakistan is similarly remote. None of these countries has any current reason to threaten the UK. If the political climate were to deteriorate, it is just conceivable that a nuclear threat could arise. However it is again necessary to suppose that the US might not exercise its responsibilities under the NATO treaty to defend an ally.

The risk of a threat from one of the 'threshold' nuclear states (Iran, North Korea etc.), or from sub-national groups, is harder to assess, but:

- it would have to take the necessary steps clandestinely to develop both a nuclear weapon (or other WMD) and associated delivery capability, and then choose to threaten the UK;
- it would have to be susceptible to being deterred by the threat of a nuclear response from the UK – some states in this group might be undeterred, having the 'suicide bomber' mentality, and some sub-national groups might be indifferent to damage inflicted on their 'host' country.

Overall, we conclude that the arguments for retaining an independent UK capability based on strategic deterrence have very largely lost whatever force they may have had during the Cold War years.

2. Strategic use of nuclear weapons by the UK during war

Even in the era of nuclear deterrence, the UK has on at least seven occasions been at war (on its own or in alliance with others) with another state – Korea, Suez, Falklands, Gulf War, Kosovo, Afghanistan, Iraq – and it cannot be excluded that such a situation could arise again. In each of the conflicts named, the adversary did not at the time actually possess nuclear weapons or other WMD in a form such that they could threaten the UK, and only in the case of Iraq was there judged to be a possibility that it might possess such weapons. However in some future conflict, the adversary might actually possess such weapons. In either case, the UK would have to consider whether it could hope to win the war by using its nuclear weapons – the number of warheads which it possesses is (for example) substantially lower than that reckoned by US authorities to be needed to inflict *military* defeat on Russia[19]. However they could perhaps be envisaged in this role if the adversary were smaller or more vulnerable.

Even if it was decided that their use would be effective, the UK would have also to consider whether it was prepared to use a nuclear weapon, either as retaliation for a previous act of the adversary or as a pre-emptive strike. It seems that even comparatively recently, the government was prepared to consider that it might. Malcolm Rifkind, for example, suggested in 1993[20] that UK nuclear weapons might be used in reply to enemy nuclear strikes or in reply to enemy use of weapons of mass destruction, for which the UK possessed no like-for-like retaliatory capability. However in none of the previous seven wars has it actually chosen to do so, and in most of those cases (the Falklands being a possible exception[21]) it is doubtful whether the adversary believed that such a strike was conceivable. We conclude that it is unlikely that the UK would choose to use its nuclear weapons in a future conflict, for the same reasons as have applied in the past fifty years.

3. A 'sub-strategic' role

Although the UK government has not spoken publicly about the scenarios in which this role might appear, two specific cases where a low-yield weapon might be used have been discussed publicly:

- A demonstrative strike, possibly against a country which did not itself possess a nuclear capability aimed at a non-critical, possibly uninhabited area, with the message that if it pursued its present course of action, nuclear weapons would subsequently be aimed at other more critical targets;
- A punitive strike, where a country has committed a hostile act, despite specific warning that to do so would incur a nuclear strike.

One problem with this concept is that even a very small nuclear weapon – say one with a 1 kt warhead – has a lethal area of roughly 2 km^2.

There are no cases where the UK has ever made such threats, and the balance of British public opinion seems to be strongly against doing so. Both in the Korean War and in the aftermath of the 9/11 attack, when some influential figures in the US were suggesting such uses, British media comments were wholly negative.

We conclude that this role is unlikely to be invoked in practice.

4. A 'tactical' role

That is to achieve military objectives on the battlefield which might be difficult to achieve in other ways. This was current in UK military thinking (and elsewhere) in the 1960s, but since NATO phased out battlefield nuclear weapons in 1991, this concept has disappeared from UK military doctrine. However the US has recently revived this concept, and has provided funding for development of the 'Robust Nuclear Earth Penetrator'[22] for 'bunker-busting' – i.e. attacking heavily-protected sites such as underground bunkers or caves, like those used by al-Qaida. There are serious doubts about whether it could achieve this objective without substantial release of radioactive material above ground. The US also envisages the use of small nuclear weapons for the destruction of localised facilities for terrorist weapon production or training.

The UK MoD has made no public statement on this, but there are press reports that it is considering the deployment of such weapons on a successor to Trident[23]. Both these ideas have been very widely criticised by military experts in the UK on both military and moral grounds[24], and it seems rather unlikely that they will ever become part of UK policy. There is also a widespread appreciation within UK public opinion of the risks involved in crossing the nuclear threshold in a conflict.

Summary

Whether or not the case has been stronger in the past, the arguments in favour of an independent British nuclear deterrent are now rather weak. Of the four possible missions for the 'independent deterrent' described:

- the *Strategic Deterrence* mission is undermined by the incredibility of scenarios in which it would ever be used independently of our allies;
- the *Strategic use in war* mission is rendered implausible by the fact that it has not actually been used during the seven wars in which the UK has been involved since 1945;
- the *Sub-strategic* role has never been supported by UK public opinion, and
- the *Tactical* role has been widely criticised in the UK on technical, military and moral grounds.

Why might Britain nevertheless seek to retain its nuclear weapons capability?

Even if the military arguments in favour of the UK independent deterrent are rather weak, there are some other arguments which are sometimes deployed[25]:

- *It helps to maintain a multiplicity of military/political decision centres.* It is argued that it is unwise to give any one country a monopoly in decision-taking on nuclear matters. However if the alternative 'decision' centres are in fact unable to take a rational decision to act independently, this argument is spurious.

- *As a counter to nuclear blackmail by an adversary.* The problem here is whether an adversary would be impressed by a counter-threat which it did not believe to be enforceable.
- *A seat on the Security Council, influence on the Pentagon etc..* The 'influence' argument, historically made famous by Nye Bevan's warning to the Labour Party Conference in 1957 of the danger of Britain 'going naked into the conference chamber', is not easily formulated rationally: however it is perceived to have force in the world of domestic politics, and resonates with concepts such as 'sovereignty'. It is unlikely that abandonment of its nuclear deterrent would, by itself, affect the position of the UK in the Security Council, and historically the possession of the independent deterrent has not won it a seat in some key disarmament negotiations (e.g. SALT and START were firmly bilateral), nor has it helped it much in its (vainglorious?) aspiration to 'punch above its weight in world affairs'. More recently, this argument has re-surfaced in the form of the claim that the possession of nuclear weapons increases the influence of the UK on thinking in the Pentagon. Recent history relating to Iraq must put a large question mark against that argument. However there is no doubt that possession of nuclear weapons has contributed to the UK self-image over the years.
- *The use of the UK capability as a bargaining counter in multilateral disarmament negotiations.* It is argued that unilateral renunciation of nuclear weapons could actually impede progress in overall disarmament, because such negotiations involve the trading of bargaining chips. It is also noted that as the two predominant powers reduce their inventories, the relative importance of the smaller inventories of countries, such as Britain, increases. This might be particularly important at the stage when the world is approaching complete nuclear disarmament, and the few remaining weapons are held to deter rogue states or terrorists. The chief problem with this argument is that it has been around for several decades, but the international disarmament negotiations are not making any very rapid progress.
- *The UK weapons are part of its contribution to NATO.* This argument is often repeated by Ministers, who nevertheless also wish to stress its 'independence'. It is not a very strong argument: the UK inventory is less than 3% of the total NATO inventory, so its loss would not materially affect the situation. If the UK were to renounce the capability, it would in due course have a further £1.5 billion p.a. to spend, which it might theoretically choose to make available to NATO for other military purposes.

Why might Britain prefer to abandon its nuclear weapons capability?

In addition to the absence of a plausible military role for its nuclear weapons, there are some more general arguments:

- *The use or threat of use of nuclear weapons is illegal and/or immoral.* These two arguments are distinct but closely related. There has been much discussion in recent years about the status of nuclear weapons under international law[26]. The International Court of Justice issued an Advisory Opinion in 1996[27] to the effect that:

> the threat or use of nuclear weapons would generally be contrary to the rules of international law applicable in armed conflict, and in particular the principles and rules of humanitarian law;
>
> However, in view of the current state of international law, and of the elements of fact at its disposal, the Court cannot conclude definitively whether the threat or use of nuclear weapons would be lawful or unlawful in an extreme circumstance of self-defence, in which the very survival of a State would be at stake;

This opinion rested heavily on the United Nations Charter, which invokes the concept of proportionality of force to the objectives in an armed conflict, and on the Hague and Geneva Conventions, which are at the core of 'international humanitarian law'. The UK MoD, unsurprisingly, invokes the uncertainty in the final clause of the Opinion to claim that the UK policy is not illegal.

The question of the morality of the threat or use of nuclear weapons has been discussed by many philosophers and theologians (not to mention a few Generals), frequently invoking the doctrine of the 'Just War' which has been widely cited since the times of St. Thomas Aquinas (to whom it is mainly attributed). This doctrine includes two criteria – proportionality and discrimination – which most uses of nuclear weapons would seem to violate.

- *The possession of nuclear weapons by a relatively small country like Britain encourages proliferation.* At the time when the NPT was being negotiated, a number of eventual signatories emphasised the importance of the part of the treaty which commits the five nuclear weapon states (as they then were) to taking serious steps towards nuclear disarmament, and many of these have expressed dismay at the failure to honour this commitment. Other countries have refused to sign the NPT, citing this as a reason. The number of countries that have acquired nuclear weapons since the NPT came into force, or are on the threshold of doing so, is rising, and the international community is rightly concerned at the rate at which proliferation is proceeding. Although it is difficult to prove, it is likely that the example of relatively small countries such as Britain possessing nuclear weapons, and apparently gaining international prestige through doing so, is encouraging other similar countries to follow suit.
- *A nuclear posture is liable to give rise to fatal misunderstandings.* A nation which is subject to an incoming nuclear missile attack has very little time to decide where the missiles are coming from, and how it should respond. If the missiles are submarine-launched it may be impossible for the target country to determine their country of origin. The UK submarine-based nuclear posture therefore makes it possible for a country subject to such an attack to have the mistaken belief that it had been launched by the UK, and in consequence initiate nuclear retaliation against the UK.
- *Britain would be particularly vulnerable in a nuclear war, because of its high population density, and less so if it renounced nuclear weapons.* Britain has one of the highest population densities on earth (244 per km^2) and its three largest cities (London 11.8M, Birmingham 2.6M and Glasgow 1.6M) account for 27% of its overall population (60M). So even a small number of nuclear weapons would inflict quite unacceptable damage. Lord Rothschild[28] made this point very strikingly: a strike consisting of one 20 megaton and 9 one megaton weapons would be sufficient to destroy the whole of British civilisation – not merely the 10 cities targeted, but the vast and delicate infrastructure (utilities, food supplies, communications and transport) on which we all rely. This makes the UK vulnerable to nuclear blackmail. Its nuclear deterrent is concentrated in four submarines, only one of which is normally at sea, so an adversary would have a relatively strong incentive to make a pre-emptive strike on the other three. Renunciation of its nuclear deterrent would remove this risk.
- *The UK deterrent will be vulnerable to the development of ABM systems.* There is widespread recognition that it is not feasible to develop an ABM system which would give complete protection to a country the size of the USA or Russia against the nuclear capability which those two countries currently possess. However it is less obvious that it would be impossible to deploy an ABM system which would provide effective protection against a capability such as that of the UK. It is arguable that this is precisely

what the USA is currently seeking to achieve, citing the threat from rogue states and terrorists, but nevertheless tending to make the UK deterrent to some degree obsolete. To overcome this threat in full while retaining full 'independence' would require a major expansion of the UK capability. It is much more likely that the UK will seek to shelter under the US ABM umbrella, thereby becoming even less 'independent'.

- *The vast misuse of financial resources involved in maintaining it.* We have seen that the UK has spent some £50 billion on its nuclear deterrent to date, and continues to spend at a rate of £1.5 billion p.a. It is unlikely that any replacement for Trident would cost less than Trident. These figures are not enormously large compared with the UK GDP (~£1000 billion p.a.), but they are very large in relation to either the cost of many alternative sources of security or the cost of many Public Goods that the British electorate might value (£50 billion would buy 500 UK city hospitals, 70 1GW nuclear power stations, provide drinking water and sanitation for the entire developing world or clear all of the world's landmines).

Balancing the arguments for and against abandonment of the UK nuclear capability

Of the five arguments cited in support of the retention of the UK nuclear weapon capability, none is strong, and some have been seriously undermined by 50 years of history, whereas all of the arguments for the abandonment of the capability have force, and four are particularly strong:

- The absence of a plausible military role for an *independent* UK nuclear capability
- The high vulnerability of the UK in a nuclear war
- The misuse of scarce financial resources involved in maintaining the capability
- The encouragement which the UK capability gives to proliferation.

Conclusion and Recommendations

We conclude that it would be rational for the UK government to adopt a policy of nuclear disarmament. Given the current state of public opinion, we judge that it would be sensible to proceed by stages, in agreement with our NATO allies, but without making these stages conditional on any matching action by any other government.

We recognise that, as recent UK opinion polls show, there is no very strong public interest in this issue at present. There is therefore a need for government leadership.

The British Pugwash Group is recommending three actions which the government could take soon, which are compatible with the longer-term objective but may be more readily achievable in the short-term. These are not mutually exclusive, and could be taken individually or in various combinations:

1. Intensify work towards multilateral disarmament.
2. Make a unilateral reduction in the UK nuclear arsenal.
3. Make a commitment not to develop or procure a nuclear successor to Trident.

These are explained in more detail below.

1. Intensifying Work towards Multilateral Nuclear Disarmament

The UK has an obligation under the Non-Proliferation Treaty to pursue measures of multilateral arms control and disarmament. It also has a vested interest in the success of such measures. And in fact over the past two decades the UK has demonstrated an ability to contribute positively to multilateral arms control, e.g. in relation to Chemical Weapons. If the UK were to show a more determined commitment to nuclear disarmament, it could expect to become a leading member, if not the leader, of the group of states actively working for the creation of a nuclear-weapon-free world. Specific policies which it could pursue include a fissile material cut-off treaty, and a 'no first use of nuclear weapons' policy for the UK and NATO.

2. Unilateral Reduction of the UK Nuclear Arsenal

A modest further reduction in the number of UK warheads, below the current inventory, could be made without undermining the logic behind the original choice of four submarines with up to 48 warheads per submarine. This should be presented as a step towards ultimate nuclear disarmament.

3. A Commitment Not to Replace Trident

The most important recommendation is that the UK government should make (and announce) an early decision not to develop or otherwise procure a nuclear successor to Trident, and commit to decommissioning Trident at the end of its design life, say on the 50th anniversary of the NPT in 2020. This would show a recognition that the policy on nuclear weapons was changing, and that they were no longer seen as indispensable. It would set a timetable on which the UK would meet its disarmament obligation under the NPT, and increase pressure on the other nuclear weapon states to do likewise. The policy could (and should) be supported by further actions which would provide tangible evidence that UK policy could not readily be reversed:

- A reduction of the UK's stockpile of military plutonium to the minimum required to see out the Trident system – about 1 tonne
- A commitment not to produce or acquire tritium for military purposes, following the closure of Chapelcross
- A fundamental reassessment of the role of AWE Aldermaston (analogous to that being planned in the Russian Closed Nuclear Cities).

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Chemical Weapons and International Cooperation

Julian P Perry Robinson

An international treaty that took effect in 1997 outlaws weapons that work through the toxic properties of chemicals in man or other animals. Scientific progress is changing the technologies that can foster these weapons, and the world, too, is changing. How well can that treaty – the 1993 Chemical Weapons Convention – be expected to survive both political and technical change?

To describe what is at stake, I shall show four images that I will discuss in turn. The first is an aerial photograph taken nearly 90 years ago of a battlefield in Flanders. The second is a recent view of the Indian city of Bhopal, where thousands of people died after chemicals escaped from a factory in December 1984. The third is a street scene in the Iraqi town of Halabja just after government forces had attacked it with chemical weapons in March 1988. The final image is a press photograph of Russian soldiers in October 2002 carrying bodies out of a Moscow theatre where antiterrorist chemical weapons had been used to free an audience taken hostage.

Many chemicals have aggressive properties that can be used for weapons purposes – explosive chemicals and propellants, most obviously, but also incendiaries, flame agents, obscurants, radio-active substances and others. Those used in so-called 'chemical weapons' are exploited primarily for their toxicity, which is to say their ability to cause death, temporary incapacitation or permanent harm through chemical action on life processes.

Toxic chemicals, including those popularly thought of as 'poisons', have been used as weapons since ancient times, just as they have been for murder, and judicial killing. Something radically new happened on 22 April 1915 at Ypres, in Belgium, during the First World War. Chlorine gas – familiar today from public swimming-pools and the like – became the world's first "weapon of mass destruction". The first of my four images shows how. German forces had laboriously emplaced some six thousand cylinders of compressed chlorine gas along seven kilometres of front-line trenches opposite the French position on the Ypres salient, between the villages of Bikshote and Langemark. Outlets of the cylinders in groups of ten were linked through a manifold to an emission hose. When the direction and strength of the wind finally became favourable, the hundreds of stopcocks were opened to release a great volume of heavy asphyxiating vapour into what was a gentle late-afternoon breeze. The 'poison gas' rolled unstoppably into the French trenches where it seems that everyone who could do so fled to escape it, the majority (according to some accounts) unsuccessfully. A similar attack next day hit the adjacent Canadian sector. Five thousand people are said to have been killed by the chlorine and another 15,000 wounded. It was the future Nobel laureate Fritz Haber who had conceived and promoted the idea of cloud-gas weapons as a means for invading the protection that trenches afforded against conventional attack. He had been stimulated by the great physical chemist Walther Nernst, who had long been thinking about possible chemical solutions to the trench problem (his chief idea was tear gas spread from artillery shells).

The German chlorine onslaught ruptured the Allied defence lines, but German forces had made no preparations to exploit their achievement, and the trench warfare returned to its largely static condition. There was retaliation in kind, of course, and then a continuing struggle for chemical supremacy over the next three and a half years, which consumed enormous tonnages of poison and afflicted more than a million people. Except to make two general observations, I shall not go any further into this. There is a large literature about it all – of which the latest publication is one of the very best, the paper by William van der Kloot in the May 2004 issue of the Royal Society's *Notes and Records*. It has a properly

descriptive title: "April 1915: Five future Nobel prize-winners inaugurate Weapons of Mass Destruction and the academic-industrial-military complex".

The first observation I want to make is that it was not from military arsenals or even from military science that that novel and potentially war-winning weapon – massively discharged cloud gas – originated, but from civil industry. The new weapon exploited a particular German industrial advantage: capacity for large-scale liquefaction of chlorine gas, a bedrock chemical in a sector of manufacturing industry in which Germany was then pre-eminent. This was the first major manifestation of the circumstance we nowadays call "dual use": a technology that has both a peaceful side and a weapons side. It is here that the "international cooperation" of my title chiefly comes in: the procedures agreed among nations 88 years later for assuring one another that their dual-use chemical industry was not being abused in covert preparation for chemical warfare. That is where the primary value of the 1993 Chemical Weapons Convention resided and continues to reside.

Table 1. Weapons versus protection

Novel weapon	Example of weapon	Induced countermeasure
asphyxiating vapour	chlorine	thiosulphite-impregnated hoods
toxic vapour not absorbed by thiosulphite	phosgene	hexamethylenetetramine-impregnated hoods
much heavier concentrations of current agents	larger munitions, or TOT artillery fire	respirators with activated-charcoal filters
toxic vapour not readily adsorbed on charcoal	hydrogen cyanide, cyanogen chloride, perfluorisobutene	impregnants added to respirator charcoal
toxic particulate aerosol	diphenylchloroarsine	particulate filter added to respirator
skin-burning liquid spray	mustard gas, lewisite	protective clothing as well as respirators
agents toxic at smaller, even imperceptible, airborne dosages	1st and 2nd generation nerve gas: tabun, sarin	mask on warning; automatic field detectors; antidote-autoinjectors
supertoxic percutaneous agent	3rd generation nerve gas: VX, VR	better protective clothing
toxic (per)cutaneous agent adsorbed onto fine dust	dusty mustard etc.	even better protective clothing and respirators; prophylactic drugs
supertoxic IVA (intermediate volatility agent)	Soman	
agents not detectable by existing alarms or otherwise able to evade some standard countermeasures	4th generation nerve gas: Novichoks	better detectors, decontaminants and antidotes

My second observation has to do with what it actually was that made those gas-cylinders into a weapon of mass destruction (WMD). It was environmental mediation. Uniquely among the weapons systems of the time, ambient air was a key component of the system. Through massive air pollution, it conferred the effectiveness over wide areas that enabled mass killing in a short period of time.

Yet that same feature also facilitated protection against the new weapon. A simple filter interposed between individuals and the air they breathed – the "gas mask" or respirator – could in principle negate the mass-destructiveness of the weapon; likewise, later, a shield of protective clothing interposed between the skin and droplets of skin-acting liquid poison, such as mustard gas or some other blister agent. Maybe 'negate' is too strong a word. For

disciplined, trained and well-equipped soldiery, perhaps; but for civilian populations, no, though some small rich countries have gone on attempting it. Anyway, as the Great War ground on and as nations subsequently built upon its experience, a novel form of technological arms race set in: weapons versus protection, and vice versa. Protection tends to win, as Table 1 shows.

Image 1. Courtesy US National Archives. *Gas and flame attack.* SC 10879 EU – MIB

Where did that ascendancy of protection leave the military usefulness of chemical weapons? On the battlefield their utility became dominated by the state of the other side's protective measures. If there are no gas masks, no protective clothing, the weapons remain WMD. But if there is good protection, that property may be lost. This is perhaps why, since the First World War, chemical warfare has happened only in the Third World, where good protection has rarely been available. This is shown in Table 2 below.

Yet even in the high-tech environment of the Cold War, protection was not thought to have rendered chemical weapons useless in war between industrially advanced belligerents. On the contrary: protection provided a *raison d'être* . Chemical weapons could force enemy troops into the encumbrance of protective posture – clumsy gas masks, hot NBC (nuclear, biological and chemical protective) suits, thick gloves – degrading their combat performance. Marginal comparative advantage on the battlefield could, it was believed during the nuclear-armed confrontation in Europe, tip the balance.

Thus the notion of like-with-like chemical-warfare deterrence, which arose at the strategic level during the Second World War perhaps thereby keeping chemical weapons off most of the battlefields of that war, perpetuated itself thereafter at the tactical level. Huge quantities of second and third generation nerve gases (see Table 1) were accumulated for

Table 2. Authenticated instances of battlefield or terrorist use of toxic antipersonnel chemicals since World War I

Period	Location of use	Toxic chemical used	(trivial name)
1919	North Russia	bis (2-chloroethyl) sulphide	Mustard gas
		10-chloro-5, 10-dihydrophenarsazine	Adamsite, or DM
		diphenylchloroarsine	Clark I, or DA
1923-26	Morocco	bis (2-chloroethyl) sulphide	Mustard gas
		bromomethyl ethyl ketone	Bn-Stoff
		trichloronitromethane	Chloropicrin
1935-40	Abyssinia	bis (2-chloroethyl) sulphide	Mustard gas
		carbonyl dichloride	Phosgene
		chlorine	Chlorine
		ω–chloroacetophenone	CN
		diphenylcloroarsine	Clark I, or DA
		phenyldichloroarsine	PD
1937-45	Manchuria	bis (2-chloroethyl) sulphide	Mustard gas
		carbonyl dichloride	Phosgene
		ω–chloroacetophenone	CN
		2-chlorovinyldichloroarsine	Lewisite
		diphenylcyanoarsine	Clark II, or DC
		hydrogen cyanide	AC
1963-67	Yemen	bis (2-chloroethyl) sulphide	Mustard gas
		carbonyl dichloride	Phosgene
		ω–chloroacetophenone	CN
1965-75	Vietnam	2-chlorobenzalmalononitrile	CS
1983-88	Iran/Iraq	bis (2-chloroethyl) sulphide	Mustard gas
		2-chlorobenzalmalononitrile	CS
		ethyl N,N-dimethylphosphoroamidocyanidate	Tabun, or GA
		O-cyclohexyl methylphosphonofluoridate	Cyclosarin, or GF
		O-isopropyl methylphosphonofluoridate	Sarin, or GB
1994-95	Japan	O-isopropyl methylphosphonofluoridate	Sarin, or GB

Source: World Health Organization, *Public Health Response to Biological and Chemical Weapons*, Geneva: WHO, 2004, p 35.

battlefield scenarios, which, if acted out in Europe according to the war plans, would have left soldiers relatively unharmed but not the downwind non-combatants, who, unprotected, might have died in their millions. By which time nuclear warfare would surely have begun, rendering the nerve gas utterly otiose.

For my second image I move away from Europe to Asia, not to Indochina (where, in the forms of tear gas and herbicides, chemical weapons were massively used during the Vietnam War of 1961-75[1]) but to India. The image is of the city of Bhopal, the site of a terrible chemical-industry catastrophe during the night of 2-3 December 1984.

The photograph was taken quite recently and shows, not a sparsely populated plain as in that image of World War I mass destruction, but a densely populated urban area. The building in the middle, abutting hundreds of modest dwellings, is a now-abandoned chemical factory that had been built to make the pesticide carbaryl, or, as the factory-owners Union Carbide called it, Sevin. This was done by a process involving methyl isocyanate (MIC), which is an industrial intermediate of substantial toxicity (by civil if not military standards)

and high vapour tension. For reasons that are still not entirely clear, a large storage tank vented tens of tons of MIC into the soft breeze over a night-time city under meteorological conditions that favoured accumulation of high airborne dosages of the poison at ground level. Four thousand people were soon dead from their exposure, and 50 times that number were injured. Of those 203,000 people injured, more than 20,000 were permanently harmed, and another 10,000 have died a premature death.

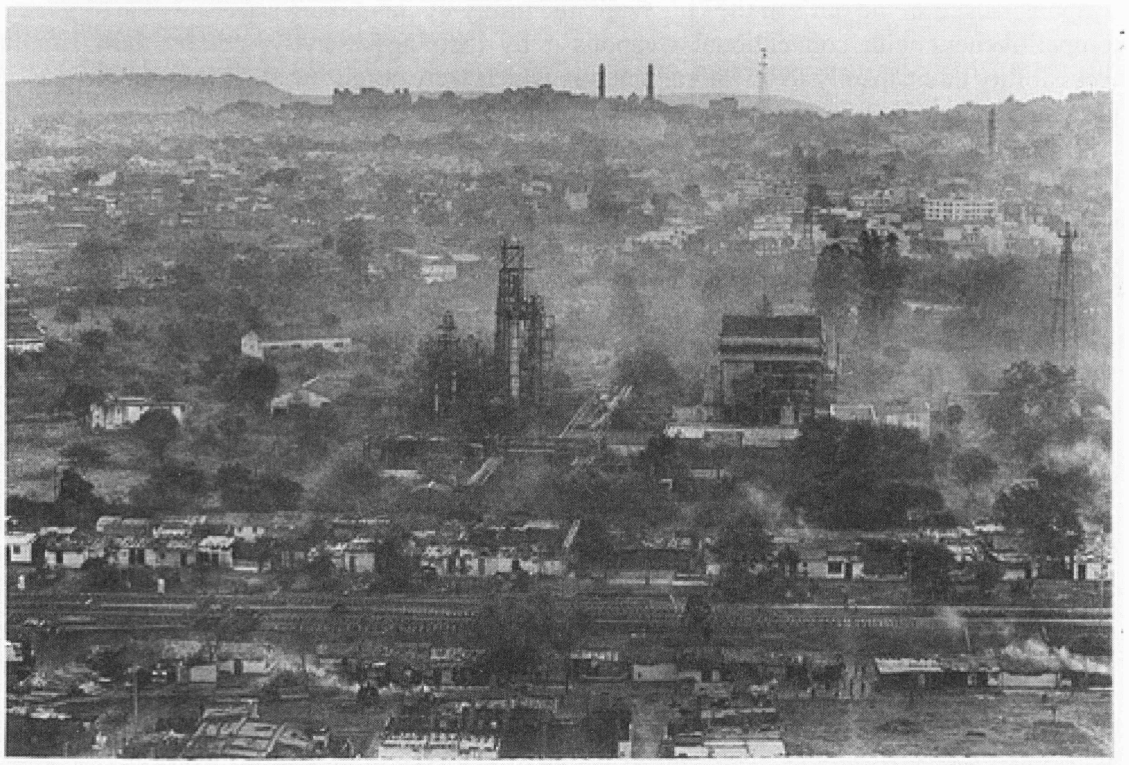

Image 2. Greenpeace/Raghu Rai. *Photoessay:Remembering Bhopal,* no. 19, "A view of the abandoned Union Carbide pesticide plant". http://www.outlookindia.com

There is a large literature on this calamity[2], so I shall not go into it any further, but I want to make two general observations. The first is that the number of lethal doses of MIC mobilized and made airborne during that terrible event was probably about the same as the number of lethal doses of nerve gas that can be set loose from the warhead of a single Scud missile. The Bhopal event therefore reminded the world of the vulnerability of cities towards chemical weapons. It lent awful substance to the idea of nerve gas as a poor man's nuclear weapon.

Secondly, that comparative estimate also illustrates how immensely aggressive specially developed chemical-warfare agents are as compared with toxic chemicals found in civil industry. This divergence grew wider as the Cold War advanced and, with it, the emergence of still more aggressive chemicals. The key development criterion was that a given expenditure of chemical munitions – shells, bombs, rocket warheads etc. filled with toxic chemicals and suitable dissemination devices – should be competitive in lethal effectiveness with the same expenditure of conventional munitions, which were themselves becoming deadlier as their development continued. If there were no such comparative

advantage, there would be no military point in incurring the odium of illegal resort to chemical warfare, and, as a deterrent, the weapons would lack credibility.

Yet, like the chlorine cylinders of Ypres, the Bhopal catastrophe showed that dreadful harm could be caused by civil chemicals, if circumstances favoured it. Hence our concern today about chemical terrorists, who may be able to access toxic industrial chemicals (known as TICs in the antiterrorism business) where they could not access nerve gas. And not only terrorists: TICs may have a utility in the New Wars[3] that chemical weapons lacked in the old[4]. In the Old Wars, the utility of chemical weapons was set by their competitiveness with conventional weapons – by their aggressivity, not by their simple accessibility and capacity to terrorize, features which were surely what stimulated the use of TICs as weapons in the Bosnia war, for example, and in Chechnya[5].

Table 3. Countries that have declared post-1945 chemical-weapons capability to the OPCW

[a]	Countries that have declared to the OPCW factories where chemical weapons had been made after 1 January 1946
	Bosnia & Hercegovina
	China
	France
	*India
	Iran
	Japan
	*Libya
	*Russia
	Serbia & Montenegro
	*South Korea
	United Kingdom
	*United States of America
	*also declared possession of chemical weapons
[b]	And one country that declared possession of chemical weapons but no factories
	Albania

My third image dates from March 1988 and shows the actuality of what the Bhopal catastrophe portended, anti-civilian chemical warfare on a large scale. The photograph was taken outside a dwelling in Halabja, in the Kurdish part of Iraq. The Baghdad regime has just bombed the town, its own citizens, with nerve gas and mustard gas. The nerve gas has killed so quickly that these people seem asleep. According to one authoritative account[6], "About 5000 – 7000 of the total population of 80,000 died as immediate casualties of the attack, and a further 30,000 – 40,000 of the population were injured, many severely". In fact this was not the first time a civilian population had been targeted with chemical weapons. The Iranian border town of Sardasht had suffered that fate, on a lesser scale, nearly a year previously[7], though the politics of the Iraq-Iran War meant that we in this country hardly heard about it. Perhaps for political reasons also, an investigation of the Sardasht episode by a UN inspection team apparently remained unpublished[8]. And Kurdish villages, hundreds of them, fell victim to continuing Iraqi state chemical terrorism during 1987-88.

The chemical warfare during that first Gulf War changed many of our preconceptions, not least about the proliferation of chemical weapons. When Iraq started using mustard and nerve gas against Iranian troops in 1983, we in the West tended to suppose that the USSR had supplied them. So it was a nasty shock to discover that in fact

Iraq had made the chemicals itself out of intermediates (precursors) purchased mainly from private industry in the West and in India. Iraq also bought in plant from the West[9]. The 'dual use' problem was thus becoming transformed, and countries in North Africa and the Middle East were said to be queuing up to learn how Iraq had done it. Proliferation of the weapons was well and truly under way, no longer confined to the NATO and Soviet blocs plus – maybe – just a few special friends. This endangered the interests of many states, particularly the rich industrialized countries, who hastily formed what became known as the Australia Group. Its participants undertook to control exports of listed chemical precursors and, later, of listed items of production equipment[10].

The Iraq events also gave a huge boost to the multilateral arms-control talks on chemical weapons that had been proceeding in Geneva since conclusion of the 1972 Biological Weapons Convention. With complete global chemical disarmament as the arms-control objective, these talks were addressing chemical weapons from the demand side as well as from the supply side that was concerning the Australia Group. International cooperation through the rules and procedures of a treaty regime was seen as the best way of coping with dual use. Before showing my final image I shall describe something of the course of these talks, which culminated in the 1993 Chemical Weapons Convention (the CWC).

International law, mainly in the form of the 1925 Geneva Protocol, already prohibited resort to chemical warfare. Now the aim was to outlaw the means of chemical warfare as well as its use. This could be done effectively only by the imposition of controls on chemical industry worldwide that would suppress abuse of dual-use potential with as little impact as possible on normal peaceful activities. From the mid-1980s onwards, the industry itself was pushing for diplomatic action, no doubt embarrassed by the revelations about Iraq.

By 1992 a text was agreed[11]. It was opened for signature the following year. Then began what proved to be a four-year task of building the international organization known as the OPCW – Organization for the Prohibition of Chemical Weapons – that would oversee implementation of the treaty, including operation of its international verification system in collaboration with the National Authorities of the states parties. This mammoth task was achieved under the leadership of a British chemical engineer turned diplomat, Ian Kenyon. It is something in which we can take pride.

The OPCW is headquartered in The Hague and has 500 international civil servants in its Technical Secretariat, 200 trained inspectors among them. By the end of 2004, the OPCW had 167 member states and, of the other 27 or so countries in the world that could join, 16 had signed the CWC but not yet ratified it. International take-up has thus been impressive, even though there are still important holdouts in the Middle East and on the other side of Asia.

The CWC requires its state parties to declare their holdings of chemical weapons and factories for making them so that the OPCW can then check their destruction or elimination. There have been some surprises, as Table 3 opposite shows. Few people expected as many as 13 of the states parties to declare chemical-weapons capability. Of the chemical weapons declared, seven toxic chemicals constitute more than 95 percent of the total tonnage. All are blister or nerve agents. They are identified in Table 4 below.

It is instructive to note that the most heavily stockpiled chemical-weapon agent is also the newest, a Soviet nerve gas commonly known as R-33 or VR whose chemical identity the Soviet Union sought to conceal throughout the treaty negotiation. The OPCW Technical Secretariat for some reason calls it VX, which is the symbol used by NATO for one of the US nerve gases.

Table 4. Toxic chemicals declared as chemical weapons to the OPCW

Of the total tonnage declared, these chemicals comprised more than 95 per cent		Year of initial industrial-scale production	Declared holdings (metric tons, rounded)
chemical name	trivial name		
O-isobutyl S-2-diethylaminoethyl methylphosphonothiolate	VR (R33)	1972, in USSR	15,600
O-isopropyl methylphosphonofluoridate	Sarin (R35, GB)	1952, in USA	15,000
bis (2-chloroethyl) sulphide	Mustard (R74, H)	1917, in Germany	13,900
O-pinacolyl methylphosphonofluoridate	Soman (R55, GD)	1967, in USSR	9,200
2-chlorovinyldichloroarsine	Lewisite (R43, L)	1918, in USA	6,800
O-ethyl S-2-diisopropylaminoethyl methylphosphonothiolate	VX	1961, in USA	4,000
bis (2-chloroethylthioethyl) ether, 40% (rest mustard)	Runcol (HT)	1938, in UK	3,500

Note: Chemical weapons, in the sense of the 1993 Chemical Weapons Convention, include all ***"toxic chemicals and their precursors except where intended for purposes not prohibited under this Convention, as long as the types and quantities are consistent with such purposes"*** [CWC Art II.1].

Included in Table 4 are figures on the total tonnage of each agent declared. To set into perspective such quantitative data, which are important for an adequate understanding of the problem of chemical weapons today, Table 5 collects together a variety of reference points.

Notice, in Table 4, that even the newest of the chemical weapons entered production twenty years before the CWC was signed. Does that mean that toxicants discovered since then lie outside the treaty and can therefore be used to evade it? No! Chemical weapons, in the meaning of the CWC, are defined to include *Toxic chemicals and their precursors, except where intended for purposes not prohibited under this Convention, as long as the types and quantities are consistent with such purposes*: beautiful, prescient language setting out the so-called 'general purpose criterion' that copes at once not only with the 'dual use' problem but also with the problem of still-secret or as-yet-undiscovered chemical-warfare agents.

Have there been any such discoveries? Yes. Table 1 above has an entry for "fourth generation" nerve gases – the so-called Novichoks. And novel substances that combine high toxicity with low lethality are actually being weaponized, the CWC notwithstanding.

These last include chemicals that serve the interests of those who are pushing into public expenditure, for police or military service, the concept of 'non lethal' weapons technology, and they bring me to the last of my four images.

This is late October 2002 outside a theatre in Moscow. A musical had been playing there two days previously when its audience of some 800 people were taken hostage by armed Chechen activists. The 50 hostage-takers included women with explosives strapped around them, ready to be detonated upon command. The photograph shows bodies – "dazed hostages" according to its caption in *Time* magazine – being carried out from the theatre after just such a 'non lethal' weapon had been used to liberate them. There were more than 170 deaths, including most, perhaps all, of the hostage-takers, who had been shot dead.

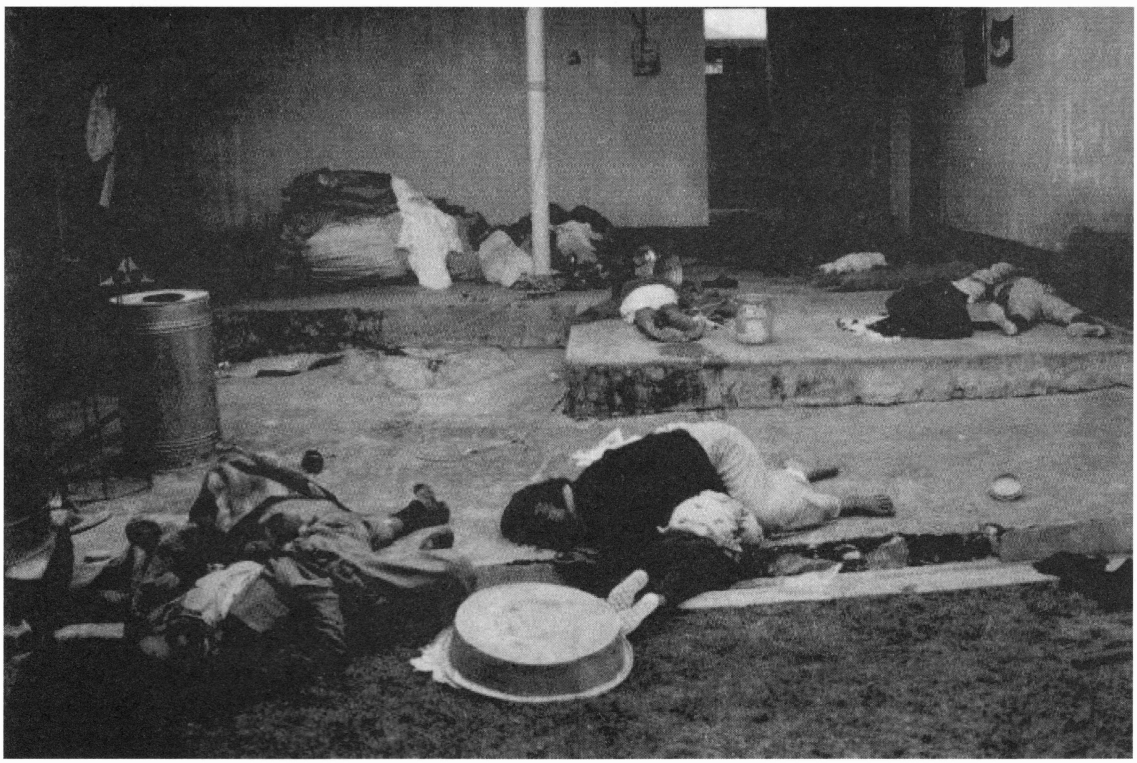

Image 3. "Victims of the chemical attack on Halabja", by Ahmad Banakashani, in *A Photo Report on the Chemical Massacre in Halabja by Iranian Photographers* , Iran Photo Foundation, May 1988, p. 27.

Image 4. "Theatre of War: Russian special forces end the hostage crisis. Carried out by rescuers hostages were dazed from the gas." *Time* magazine, vol. 160 no. 19 (4 November 2002).

Table 5. Tons of toxic chemical: significance indicators

Metric tons of toxic chemical —	**Total**	**UK only**		
Used as weapons in World War I	120,000	14,000		
Stockpiled in World War II	400,000	55,000		
Stockpiled at onset of Cold War	325,000	62,000		
Declared as chemical weapons by states parties to the CWC, 1997 on, now being destroyed	71,400	0	Russia USA India South Korea Albania Libya	40,000 27,800 x 2100-x 16 24*
Stockpiled as chemical weapons today by states not parties to the CWC	???	—	Egypt Iraq Israel North Korea Syria	?? 0 ?? ?? ??
Released at Ypres, 22-23 April 1915 (chlorine)	150	—		
Used as weapons by USA during Vietnam War, 1961-75 — Herbicide CS gas	82,000 7,800	—		
Used as weapons by Iraq during its war with Iran, 1981-88	2,540**			
Destroyed in Iraq under UNSCOM supervision, 1991-98	800*			
Discharged over Bhopal, 2-3 Dec. 1984 (methyl isocyanate)	30	–		
Needed for effective attack on a 50-200 hectare battlefield target — HCN Mustard VX CS Sarin	50 7 4 2 1	—		

* Plus some thousands of tons of precursors

** The final report of the Iraq Survey Group states that Iraq declared consumption of 1800 tons of mustard gas during the war, 140 tons of tabun and over 600 tons of sarin. The report presents no information on the large quantity of CS gas also used as a chemical weapon.

I do not want here to explore the issues involved or get much further into the details of what happened – save to ask this: Which way should the episode best be described:

- Non-lethal chemical weapon regrettably kills 129 of the 850 people exposed to it? Or,
- New chemical weapon triumphantly saves 671 of 800 people in mortal danger from terrorists?

The chemical agent used by the Russian security forces that stormed the theatre was an opioid formulation based on fentanyl and disseminated as aerosol. It is a further illustration of dual use, for those chemicals have widespread use as surgical anaesthetics.

Our government in the United Kingdom made no public demur at the use of opioids to lift the Moscow theatre siege. On the contrary, the government seemed to condone it – hardly surprising, one may think, as it has itself been actively studying the possibilities of

such 'non lethal' chemical weapons for decades. In the United States, the Army Chemical Corps first began examining *fentanyl* as a possible weapon in 1963[12]. Goodness knows what the Americans have come up with since then. They seem to have gotten somewhere, given the advocacy that can now be heard from across the Atlantic for amendment of the Chemical Weapons Convention so as to liberate high-toxicity/low-lethality chemicals from its strictures[13].

The point of this final part of my presentation has not been to mock or otherwise denigrate non-lethal weapons technology. It is instead to warn that the proper functioning of the OPCW is currently endangered

- not only by the possibly irrepressible propensity of 'dual use' to make at least some chemical weapons accessible;
- not only by new utilities for chemical weapons now emerging from the changing nature of warfare;
- not only by the proliferation of chemical-warfare technology to those we choose to call 'rogue states';
- but also by the emergence of a new attraction of chemical weapons to those very same rogue-callers – us – in the concept of antiterrorist chemical weapons.

Accordingly my conclusion is that the valuable international cooperation against chemical weapons established by the CWC and embodied in the OPCW is now under threat from four quite different directions.

Notes and References

1. Estimates of the total quantity of chemical herbicides and of Agent CS used by US forces during the Vietnam War derived from incomplete official data are set out in J P Perry Robinson, "Chemical and biological warfare developments: 1985", *SIPRI Chemical & Biological Warfare Studies* no. 6, 1986, at pp. 53-55.

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3. Mary Kaldor, *New & Old Wars: Organized Violence in a Global Era,* Cambridge: Polity, 1999.

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5. For an unrivalled published review of the reported use of TICs and suchlike non-military toxic chemicals as weapons, see Theodore Karasik, *Toxic Warfare,* RAND Corporation, MR1572, 2002, at pp 17-28, Chapter Three, "Recent use of and thinking about toxic weapons".

6. Christine Gosden, Mike Amitay, Derek Gardener and Bakhtiar Amin, "Examining long-term severe health consequences of CBW use against civilian populations", *Disarmament Forum* [Geneva: UNIDIR] 1999 no. 3 (August 1999) pp. 67-71.
7. Harvard Sussex Program, *CBW Events Data-Base*, record for 870628-29.
8. Letter dated 10 August 1987 from the Permanent Representative of the Islamic Republic of Iran to the United Nations addressed to the Secretary-General, distributed via UN doc. A/42/467-S/19029 of 10 Aug. 1987.
9. A major new addition to the published literature on this topic is the final report of the Iraq Survey Group, recently published by the US Central Intelligence Agency: *Comprehensive Report of the Special Advisor to the DCI on Iraq's WMD*, 30 September 2004. It is the final volume of this thousand-page report that addresses chemical (and biological) weapons.
10. For a detailed account of the early days of the Australia Group, see J P Perry Robinson, "The Australia Group and the Chemical Weapons Convention", a paper presented at the 19th Workshop of the Pugwash CBW Study Group, Geneva, 11-12 January 1992. An earlier version is published as "The Australia Group: a description and assessment" in Hans Günter Brauch, H J van der Graaf, John Grin and Wim Smit (editors), *Controlling Military Research & Development and Exports of Dual Use Technologies as a Problem of Disarmament and Arms Control Policy in the 1990s*, Amsterdam: VU University Press, and New York: St Martin's Press, 1992, pp. 157-176. For information about the Australia Group today, see its website at <www.australiagroup.net>.
11. For an account of how this happened, see J P Perry Robinson, "The negotiations on the Chemical Weapons Convention: an historical overview", in M Bothe, N Ronzitti and A Rosas (editors), *The New Chemical Weapons Convention – Implementation and Prospects*, Kluwer Law International, 1998, pp. 17-32.
12. See the entry for 630515 in J P Perry Robinson, "Disabling chemical weapons: a documented chronology of events, 1945-2003", 1 November 2003 (unpublished).
13. Described in J P Perry Robinson, "Solving the problem of 'law enforcement'", a paper presented at the 19th Workshop of the Pugwash Study Group on Implementation of the CBW Conventions, *The First CWC Review Conference and Beyond*, Oegstgeest, the Netherlands, 26-27 April 2003.

Biological Weapons: Why they are a threat

Alastair Hay

Biological warfare has a pedigree which reaches back to at least Grecian times, probably further back, when armies used the dead, putrifying carcases of animals and people to poison drinking water. Since then methods of delivery of biological agents have become more sophisticated, but the principle of spreading disease or causing ill health to hamper the enemy remains the same.

Some deliberate acts of biological warfare are recorded in the 14th and 18th centuries when attempts were made to spread plague and smallpox respectively. Whatever was responsible for plague spreading, be it the catapulting of the corpses of plague infected victims over city walls by the Tartars in 1346, or the natural migration of the black rat and its accompanying fleas, the disease did infect city inhabitants.

As for smallpox, the evidence, such as it is, suggests that in the United States, this too had a helping human hand to spread it. On one occasion it was the British Army in the US under Sir Jeffrey Amherst who gave blankets from the Smallpox Hospital to two native American chiefs regarded by the British as belonging to "disaffected" tribes. The blankets were given as presents, and received as such. Whether it was as a result of this gift from the British or some other, more direct, contact with smallpox victims the disease spread ravaging the tribes.

But it was in the 20th century that concerns about biological warfare grew apace. In the First World War biological warfare was a really distant second behind the ever present threat of chemical warfare. The attempt by German troops to infect horses with glanders was the only real evidence of some deliberate disease spreading activity. By World War II it was the Japanese who waged biological warfare by spreading plague on the Chinese populace with this action both preceded and superceded by the most horrific experimentation in Manchuria involving some 20 bacteria and viruses on 3000 human subjects, none of whom survived. The number who died as a result of biological warfare in China is unknown with estimates ranging from 10,000 to nearly 250,000. Work continues in China to firm up the estimates.

Since WWII there have been no large scale actions involving the release of biological agents. There have, however, been many significant government biological weapons programmes. The UK had such a programme which paled when compared with that of its US counterpart both in scale and in munitions developed. Had WWII continued into 1946 and had allied forces not been as successful as they were in retaking Europe, the UK, with US assistance, had plans to produce tens of thousands of anthrax bombs to drop on Germany. Manufacture of the bombs was to take place in the US out of harm's way. Production in the UK was considered too risky for the factory might be bombed and the anthrax spores infect the British public.

There are considerable difficulties involved in the production of biological weapons which is why the most successful programmes have been carried out by governments. They have the resources including skilled scientists, weapons experts and engineers and, above all, resources to see a programme through to completion. In selecting an organism to be used, a principal requirement is that it be robust and able to withstand the processes needed to make it into a weapon. Most biological agents have a limited life in storage during which their activity continues to decline, although there are exceptions to this such as anthrax, dispersal of which would be as spores, which are quite robust. In general, however, steps would have to be taken to continually replenish stocks of agents, and to slow down rates of decay by storage at very low temperatures or where possible, as freeze-dried preparations.

biologically active substances enabling these to be delivered effectively as respirable aerosols. This increases the range of substances for biological weapons way beyond the traditional bacteria and viruses capable of causing diseases in humans or animals. Plants, too, could become increasingly prone to attack with diseases as delivery systems improve. The military must remain the biggest threat for exploiting these new technologies, but the potential for other, smaller groups to do the same is increasing too.

Currently, attempts to control the spread of biological agents are driven largely by the actions of individual governments. These include laws prohibiting any involvement by citizens in biological warfare; keeping likely candidate bacteria and viruses, etc. under lock-and-key; restrictions on exports; and possible limits on what scientific journals will allow to be published. Further controls are likely and these may include restrictions on the work permissible in certain scientific fields. Discussions about codes of conduct for scientists are also on the agenda for international negotiations in 2005.

The growing recognition by scientists that their work has not just the potential for good, but may also be exploited in a harmful way is forcing debate on what is reasonable by way of controls and what will be achieved by it. The debate amongst biological scientists about potential misuses of their science can do no harm.

Whether the current activities will deliver the security everyone desires and in the absence of robust international treaties which both require compliance but can also ensure it, remains to be seen.

Candidate Biological agents for munitions.
The following diseases and how the infective organism which causes them might be delivered are but a few which have been considered for use as biological weapons:

Agents	Delivery	
Anti-personnel		
yellow fever	as an aerosol or by mosquitoes	standardised as BW agent by US
smallpox	as an aerosol or by person-to-person contact	tests on Japanese prisoners-of-war
anthrax	as an aerosol	standardised as BW agent by US and tested on Japanese prisoners-of war
brucellosis	as an aerosol	standardised as BW agent by US and tested on Japanese prisoners-of war
Anti-animal		
foot-and mouth disease	as an aerosol or contamination of water or food	
rinderpest, or cattle plague	as an aerosol or contamination of water or food	intensively researched during WWII
Anti-plant		
black stem rust of cereals	as an aerosol or dust	standardised as BW agent by US
rice blast	as an aerosol or dust	standardised as BW agent by US

About the Speakers

Dr Christopher Watson had a career spanning 35 years in the UK nuclear industry that included 17 years at Culham, working on Controlled Fusion research, culminating in 5 years on the JET project. He then worked as a research manager in Offshore Technology and Nuclear Robotics, before becoming Business Development Manager for AEA Technology in Russia developing collaborative programmes with Russian colleagues in the management of the nuclear legacy of the Former Soviet Union. Following retirement in 2002, he has been a consultant to the UK government on a range of aid programmes, including one on the nuclear legacy in NW Russia – nuclear submarines and their spent fuel and radwaste – and the Closed Nuclear Cities programme. He has also been active in the British Pugwash Group, and is a member of its Executive Committee.

Professor Julian Perry Robinson is a fellow of SPRU - Science & Technology Policy Research, University of Sussex, which he joined in 1971. With Matthew Meselson of Harvard University, he edits a quarterly journal on chemical and biological warfare armament and arms limitation that is published from Sussex, *The CBW Conventions Bulletin.*

Professor Alastair Hay is Professor of Environmental Toxicology at the University of Leeds. He has been involved with chemical and biological warfare (CBW) related issues for 25 years. Prior to this he investigated health issues associated with the use of defoliants in Vietnam. His primary interest in CBW is prevention and the need to have and support verifiable international treaties outlawing these types of warfare.

Pugwash Conferences on Science and World Affairs

What is Pugwash?

An international movement of scientists and others with a professional concern about the social impact of science and which seeks ways to prevent its misuse. Particular attention is given to banning weapons of mass destruction (nuclear, chemical, biological); to the solution of conflict without resort to force; to the creation of a sustainable environment; and to bettering the conditions of life of all people. The movement has its origin in the Russell-Einstein Manifesto of 1955, which called on scientists to meet to find ways to avert the threat to civilization created by the advent of thermonuclear weapons. It took its name from the venue of the first meeting in 1957 – the Canadian village of Pugwash. In 1995 it was awarded the Nobel Peace Prize, jointly with its then President, Joseph Rotblat.

What does it do?

It organizes meetings (8-10 a year) of scientists and scholars from all over the world with the aim of influencing government policies and public thinking on topical problems of global security. Meeting in private, as individuals representing only themselves, they are able to reach conclusions which often pave the way to governmental agreements and international treaties. The topics on the agenda of the workshops and at the annual conferences range from nuclear forces, to foreign debts, to social tensions and ethnic conflict, to the elimination of war. Reports on activities are published in the *Pugwash Newsletter* and *Proceedings of Conferences*. Pugwash also runs projects (e.g. A Nuclear-Weapon-Free World; Conversion of Military R&D; Education for World Citizenship) which culminate in books.

What has it achieved?

By providing a channel of communications between influential scientists and scholars from East and West during the Cold War period, Pugwash was able to facilitate better understanding between the adversaries, which helped to make possible agreement on important issues, such as the Partial Test Ban Treaty, the Nuclear Non-Proliferation Treaty, the Anti-Ballistic Missile Treaty and the Biological Weapons Convention. Recently it has contributed to large reduction in nuclear arsenals, the Chemical Weapons Convention and the Comprehensive Test Ban Treaty. However, much still needs to be done to secure peace in the world.

The British Pugwash Group

This is part of the network of National Groups supporting the International Pugwash Movement. Membership is open to anyone living in the UK and qualified by profession or experience to contribute to the work of Pugwash. The annual subscription of £15 (minimum) supports the activities of the Group.

The British Pugwash Group holds seminars and public meetings on relevant international as well as specific UK topics; it prepares papers for the international Pugwash meetings; and nominates paticipants from the UK to the annual conferences. It also runs research projects (e.g. an appraisal of UK nuclear weapons policy, and a study on the potential role of Aldermarston in international verification of compliance with disarmament agreements) aiming at informing public opinion and influencing government policy, especially on international security issues. It has also initiated a WMD Awareness Project, in which it is collaborating with a number of other organizations such as Greenpeace UK and BASIC, to raise public awareness on nuclear and WMD issues.

The activities of the British Pugwash Group are organized by an Executive Committee with the following membership:

Chairman: Prof. Robert Hinde
Secretary: Prof. Christopher Hill
Treasurer: Prof. John Finney

Members:	Sir Hugh Beach	Prof. Jack Harris	Dr Tom Milne	Mrs Sally Milne
	Mrs Marjorie de Reuck	Dr Carsten Rohr	Dr Christopher Watson	Ms. Joelien Pretorius
	Mr. Tim Walker	Mr. Luca Ciciani		
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	Prof. Jack Boag	Prof. William Gutteridge	Prof. Patricia Lindop	Dr Anne McLaren
	Sir Martin Rees	Mr Anthony de Reuck	Sir Joseph Rotblat	

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