Responding to the Threat of Biological Weapons

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1. One Possible Scenario

IMAGINE THIS scenario. It is four o'clock in the morning. A light breeze wafts the scent of the Persian Gulf into your tent. You and six thousand of your fellow soldiers are bone-tired from your deployment into the region and every minute of sleep is precious to you. Yet, you awaken. What is the noise you hear? It sounds something like the motor of a model airplane. Now you hear several such motors. You sleepily go outside to investigate, as do many others from the tents around you. You look up into the night sky and see what you think are small unmanned aerial vehicles – the kind you know are used for intelligence gathering. They are flying low and slow, having been launched from boats in the Gulf. You yawn deeply, thinking to yourself that it is odd so many should be overhead at once. You don't know that you are inhaling a deadly pathogen released from the vehicles. You do not know that in coming days an epidemic will sweep from your camp into the nearby towns and, within weeks, across the country. Casualties will number in the thousands, and the mission for which you have come will never be accomplished. But you won't live to know that. You will be dead in 48 hours.

What if such a scenario had occurred during Desert Shield, the buildup to Desert Storm? Would the allied coalition have remained intact, or would horrified public opinion in Western countries have demanded an end to the campaign before it started? In the future, it is quite possible that Third World nations will use biological weapons to prevent or end involvement by Western countries in regional conflicts.

The idea of biological warfare is not new, but because biological weapons have not been used prominently in recent history, they have not received much attention in strategic thinking. But the potential for BW use by nations is

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increasing.[1] Iraq admitted it had already produced stockpiles of biological weapons when Desert Storm began. Russian defectors have given credible evidence that Russia has been engineering ever more lethal pathogens for BW.[2] These examples serve as notices that the threat of purposefully spread diseases is real. The question is: What can be done about the potential of states using or threatening to use BW?

In response to the increasing BW threat, the international community has sought to bolster the 1972 international treaty which outlaws possession and use of BW – the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction (BTWC).[3] The states parties to the BTWC have mandated the creation of an ad hoc group to craft a protocol to strengthen the Treaty. Some states parties view this mandate as an opportunity to create a verification regime similar to that which exists for the Chemical Weapons Convention. This paper argues that such verification efforts are doomed to be ineffective because of the unique nature of BW, and that these measures can entail high costs for the bio-technology and pharmaceutical industries. Rather than spending effort on ineffective arms control measures, more emphasis should be placed on deterrence to forestall use or threat of use of BW.

2. ARMS CONTROL MEASURES

Although the BTWC creates a useful norm against the possession and use of BW, the treaty is limited in its effectiveness by the basic problem that no effective verification is possible.[4] As noted during negotiations for the BTWC, key problems are: the indistinguishability between legitimate bio-medical research and most weapons-work; the lack of unique facilities, technologies, materials, and equipment for producing biological agents; the small size of the staffs and facilities required for weapons-work; and the fact that weaponization activities can be readily hidden. These obstacles to meaningful verification still remain.

At the 1986 Review Conference of the BTWC, a decision was made to try to build confidence that cheating would not take place. New requirements were levied on member-states to make annual declarations of high-containment biological facilities designed for work with dangerous micro-organisms and to report outbreaks of dangerous diseases. Less than half of the states parties to the BTWC have participated in the measures. In part, this is attributable to the fact that the reporting requirements are time-consuming and, in countries with limited bureaucracies capable of handling the data, difficult to meet. Also, the requirements are viewed by many technical experts as being ineffective in deterring cheating and therefore of little benefit.

Beginning in 1991, some arms control-advocates renewed calls to strengthen the BTWC by establishing a legal requirement for nations to declare facilities and activities pertinent to BW production, as well as a regime providing for intrusive inspections.[5] The aim is to create a possibility that non-compliance would be detected, thus increasing the disincentives for proliferation.[6] Some also say that such measures would drive cheaters toward using clandestine facilities which, they argue, would be more costly and difficult.[7] Unfortunately, the difficulties in detecting clandestine production or storage of BW are profound and, as outlined below, no verification regime will offer even minimal confidence that cheating will be detected.

3. PRODUCTION OF BW AGENTS: BACKGROUND

The same problems that have made effective verification impossible for the BTWC also stand in the way of effective transparency measures. These problems are:

- A BW production facility can be very small; enough biological agent to kill hundreds of thousands of people can be manufactured in a laboratory only 25 m^2. Such a site is likely to have no distinguishing features that would enable identification of its function by outward appearance. Although one would be able to determine its purpose if access were gained during the process of agent production or even after production if there were no cleanup, there are no current technical means of locating such a facility (a requirement for asking to inspect it!).[8]
- The requisite equipment and materials to produce BW cost only several thousands of dollars and no imports are necessarily required. The glassware, centrifuges, growth media, etc. can all be manufactured by virtually any country, but they are readily available on the open market due to their pervasive use in legitimate bio-medical functions. Some people may think that growth-media imports are a telltale sign, since the UN Special Commission 'caught' Iraq on the issue of its having imported several tons of media in which to grow pathogens. While it is true that the exporter of the media to Iraq revealed that Iraq had received such a shipment and this was much more media than required for Iraq's legitimate needs, Iraq could have easily concocted the media indigenously. Iraq chose to import instead, probably, because doing so was cheap, easy, and was not perceived as risky. It can be expected that any country violating the BTWC in the future will not repeat Iraq's mistake and will make the media itself.
- BW agents do not take long to manufacture and do not have to be stockpiled over time. Large quantities of BW agent can be produced in just a few days.
- Bio-safety Level 3 (BL3) facilities – the type that would afford good protection to the personnel manufacturing BW agents – are widespread and the equip-

ment required for them is available on the open market. Thus, if a country or terrorist group wanted to construct a BL3 facility, it would be relatively easy to do. However, BL3 laboratories are not required. The early US biological weapons program, like those of other nations, did not use sophisticated safety equipment. Apparently, Iraq also did not use BL3 type facilities.

- Only a small number of knowledgeable people are needed to produce biological agents for weapons. Although a single person could conceivably produce large quantities of pathogens, it is likely that a country's BW program will involve a few people. Iraq claimed that its BW program had less than 10 people. This has implications for the likelihood that human-source intelligence will be available to help identify suspect sites: if few people are involved, information leaks will be less likely.
- Anytime, anywhere inspections are of virtually no use in locating illicit BW activities. This has been proven repeatedly in Iraq, where UN inspectors have exercised the right of anytime, anywhere inspections with no 'managed access' or other restrictions that would limit sample gathering or intrusion. The UN inspectors began searching in August 1991 for the BW production facilities and stockpiles which were believed to exist. As of August 1995, they have still not found them, although Iraq volunteered in this month that indeed it had produced and weaponized biological agents in large quantities. However, if exact and accurate human-source intelligence is available on the precise location and nature of illicit activities – such as provided in the case of defectors from the Russian BW program – it may be possible to gain further knowledge of an extant BW program through inspections if the inspectee is willing to allow them. For example, it would be possible to observe any hardened storage sites appropriate for storing BW. As in the case of Russia, however, alternative explanations may be given for the inspection findings.
- A non-compliant nation is very unlikely to declare the facility that it uses to manufacture biological agents for weapons. It is too easy and inexpensive to build a dedicated BW production site. Even if the nation were to use a declared facility, that facility will probably be used to make the same agents for peaceful purposes, thus giving a legitimate 'cover' for the presence of any telltale signs that might be discovered.

Just as the production of biological agents is difficult, perhaps impossible, to discern, so too is the process of weaponization. If a nation were to choose to enhance the virulence of a pathogen, or work to strengthen its ability to survive delivery via missiles, it could do so in the same facility as used for agent production – a small laboratory. Other weaponization functions such as lethality testing or weapons filling can be accomplished in small, non-descript facilities as well. Training for use of BW, which may be as simple as providing masks and instructions for their use, can be characterized as defensive only. It would be virtually impossible to prove that such measures were related to an offensive program.

4. SOME SCENARIOS FOR CHEATING

Any country (or subnational group) that wants to develop and manufacture BW agents secretly can do so with very low risk of detection despite any currently known verification or confidence building-measures. Some likely cheating scenarios are outlined below.

Scenario 1: A country could conduct research on pathogens using small quantities in a laboratory which may be either declared or undeclared. If declared, the work would be characterized as advanced medical or pharmaceutical research. It could even be portrayed as defensive biological work, which is allowed by the BTWC. The feedstock pathogens could then be stored.[9] No substantial quantities of agent would be manufactured, but facilities – which would be up and running, making pharmaceutical or other products – would be ready to make the agent in large quantities rapidly if the military requirement were to arise.

Scenario 2: A country could build a secret laboratory totally dedicated to the production of BW agents. The facility would be operated only as long as needed to manufacture the agents, which might be only a few days, depending on how much agent was needed and which agent was being produced.[10] Then equipment would be destroyed.[11] The agents would then be stored in containers which would be easy to move quickly.

Scenario 3: A country could produce bacteria (or their toxic products) in a pharmaceutical plant in an area where a particular disease is endemic. For example, anthrax spores could be grown in a fermenter in a region where anthrax is found in the soil. Upon warning of inspection, the fermenter could be drained and decontaminated. Trace amounts of anthrax DNA would remain and, if found as a result of inspection, could be plausibly ascribed to environmental contamination.

Scenario 4: A country could produce large quantities of BW agent(s) in commercial fermenters, for example, in a pharmaceutical facility. Within 24 hours of completing the job, which itself would only take hours, the fermenters could be changed over to producing a non-BW-related product.[12] In the interim between the products, the fermenters would be filled with acid and heated – a process which could be easily completed overnight, even if it were a large-scale facility of 50 Kl. This would make it extremely difficult to determine what had been in the fermenters previously. It might be possible to find traces of the previous agent production if highly intrusive inspections were to remove and test the seals in the fermenters,[13] but the evidence is unlikely to be conclusive, for at least two reasons. First, there are no organisms or toxins which have sole use as a weapon. All biological materials are dual-use, if only for fundamental research purposes, so identifying an organism does not mean that it was produced for unlawful intent. A cheating country can always claim peaceful intent, just as Russia has with regard to US-UK accusations of its cheating on

the BTWC. Second, small quantities of endogenous organisms can be a naturally occurring contaminant, especially if the sample analysis technique is extraordinarily sensitive, such as polymerase chain reaction (PCR). Thus, PCR can give a 'false positive'.

Scenario 5: A country could design its BW agents based on the parameters of the inspection regime. Because lists of 'agents of concern' will always be incomplete, inspectors may not have proper biological probes to detect small quantities of agents which may be produced illicitly. In general, biological probes are useful only if the inspectorate has defined exactly what it is looking for before the test is done. Otherwise, reagents (such as antibodies or gene probes) are not available. Furthermore, the country may make small modifications in the genomic and/or protein structure of an organism or toxin which can render the detection technique insensitive, giving a 'false-negative' result.

The scenarios outlined above point out the limitations of sampling and analysis as means to detect cheating. However, it should be noted that there are two circumstances in which sampling can make an important contribution to arms control – investigations of allegations of use, and of unusual outbreaks of disease.[14]

5. THE THREAT TO INDUSTRY

The proposed confidence-building measures, particularly the proposed inspections, pose a significant risk to the pharmaceutical and bio-technology industries.[15] US industries – which lead the world in development as well as sales and have more facilities that would be subject to inspection than any other nation[16] – have expressed particular concern in this regard, although the industries of some other countries, particularly Japan, have reservations also. Because US industries have been most outspoken about the potential for losing proprietary information during an inspection, and because the author has interviewed US industry representatives only, this section focuses on US industry perceptions and concerns.

The cost of bringing a pharmaceutical product to the market is approximately USD 350,000,000.[17] The organisms (which are the key to a production process) and most processes and equipment are not patented, primarily as a measure to keep them secret. Thus, there is a great degree of vulnerability. The industry is keenly competitive, and industrial espionage is a problem against which companies continually guard. As a result, US pharmaceutical companies exercise great control over who is allowed to enter production facilities, and there is a significant degree of external security.

Because there is a high level of external security, the security inside US pharmaceutical and bio-technology facilities is usually not as great. For example, information about temperatures for processes are posted clearly, computer screens for monitoring must be on and are visible, and storage areas are readily

accessible. While any one piece of information that can be gleaned from these openly available data might not reveal critical conclusions, several pieces together might.[18] To assure that such information would not be available to unfriendly eyes during an inspection, a company would have to spend significant time and money to assure that minimal information would be obtainable from the company's working environment.

There are some data which could not be protected even with a conscious effort to sanitize. For example, a pharmaceutical company would not want inspectors to see its fermenters or chemical reaction tanks.[19] From these pieces of equipment, the educated eye can learn invaluable process information which could reveal why the US company is able to manufacture a particular drug more cheaply, or why the company's product is so highly pure. Illicit air or swipe sampling, which would be virtually impossible for the company to detect or prevent, could reveal such data as which organism is being used or what unique nutrients are being used in the growth media.

In addition to the potential loss of proprietary data, there may be other extraordinarily high costs involved for bio-technology and pharmaceutical firms. If intrusive sampling is to be allowed, companies will probably have to shut down temporarily, costing as much as USD 400,000/day.[20]

An even greater cost would be incurred by US firms if false accusations were made. It would be impossible to disprove the finding of a false positive. A politically motivated inspector might say, 'On the basis of my inspection of this US facility, I believe that it is making BW agents.' Despite its being a false claim, the impact on public opinion could be profound. The credibility of the firm could be destroyed irretrievably. This scenario is not far-fetched. When the United States concluded that Russia had violated the BTWC, there were claims made in the Russian news media that trial inspections in the United States revealed that a US company was poised to make BW agents.[21]

6. DETERRENCE OF BIOLOGICAL WEAPONS

An ideal way to respond to the threat of biological weapons would be to develop and use highly effective defenses which would render BW useless to a perpetrator. This would entail having one or more of the following: safe, effective vaccines administered to all potential victims; treatments to counter the effects of any BW; and accurate, fast detection to determine when such treatments should be administered. Unfortunately, the current status of technology does not enable such defenses. Deterrence is therefore the only existing defense.

Deterrence relies on presenting an opponent with a credible threat of unacceptable retaliation. Ordinarily this would mean that any military aggression would be met with commensurate counteraction. An essential element to deterrence is that the opponent must believe that the intended victim has both

the capability and the will to retaliate. A nation wanting a military deterrent against BW threats has the options of relying on BW, conventional, or nuclear weapons.[22] The effectiveness of each is scenario-dependent. Furthermore, the choice made will depend upon variables such as whether the deterrent force will: violate international legal obligations, require acquisition or development of new technology, entail large-scale loss of life if used, or have other serious limitations.

7. A CRITIQUE OF IN-KIND DETERRENCE

Historically, deterrence vis-a-vis BW-armed adversaries has been based on the prospect of in-kind retaliation: the United States and United Kingdom developed their BW to deter BW use by others, not as first-use weapons. Following WW II, the fear of threats by nations using BW began to wane, and the US and UK BW stockpiles came to be viewed as useless. When President Nixon decided in 1972 to eliminate all US biological and toxin weapons, he did so on the advice of the US military that such weapons were not militarily useful and that the United States faced no real BW threat which required maintenance of US biological weapons for deterrence. The US Congress ratified the Treaty under the same understanding.

The notion that BW lack military utility was not universally shared. The Soviet Union, for example, continued its BW program, as was clearly demonstrated in 1979 when an anthrax weapons facility exploded at Sverdlovsk, and even later, in April 1992, when President Yeltsin issued a decree designed to end the BW program.[23] Other nations, too, continued or initiated BW programs.

Beginning in the 1980s, the ease of developing, maintaining, and using a BW arsenal was enhanced by several technological advances, including improved knowledge and control of growth parameters, genetic engineering, and sequencing. These and other technological advances made it possible to safely manufacture BW agents in large quantities and to manipulate them to maximize storability, lethality, and survivability.

Today, having a BW deterrent arsenal is the least expensive and most proportional response to BW threats. Poorer nations, many of which are not technologically advanced, will be unable to acquire advanced conventional or nuclear capabilities to counter BW, but will be readily able to develop and deploy a BW deterrent.

There are serious downsides to using BW to deter BW, however. Once diseases are used as a weapon, they do not necessarily stop spreading. The pathogen used as a BW may even mutate to more virulent forms. BW cannot be limited in its effects to a battlefield, a locale, or a people. Nor can it be limited in terms of the time during which it will harm or kill victims. The potential devastation and agony that can be caused by BW is far greater than that which may be caused by conventional, chemical, or even limited nuclear strikes.

Another problem with an in-kind deterrent to BW is that it would require abandonment of the BTWC by those nations party to the Treaty, and could stimulate proliferation.[24]

8. A CRITIQUE OF CONVENTIONAL DETERRENCE OF BW

A conventional deterrent, to be effective vis-a-vis a BW-armed aggressor, must credibly present an unacceptable retaliatory threat. The deterrent threat could be of two basic types: either a strike involving deployment in the theater of significant forces, or a standoff attack with bombers and/or missiles.

A conventional retaliation involving extensive use of manpower may not be viewed by the perpetrator as very credible. Many nations, including Iraq, have analyzed the lessons of Desert Storm. A likely conclusion they reached is that an adversary must not be allowed the luxury of time for a military buildup, and friendly ports and territory must be denied, if possible. It would not be surprising if they also concluded that one way to foreclose such conventional retaliation would be to threaten use of BW against any troops introduced into their region.

Retaliation with conventional bombs or missiles also has drawbacks as an effective deterrent. Damage from conventional warheads and bombs, even when they hit targets very accurately, is generally not devastating – as was shown in data from WW II and from Desert Storm. For example, Iraq was able to rebuild within three months a chemical facility 'destroyed' by Tomahawks. In the case of bombers, there are also a host of problems such as assuring air superiority, re-fueling for long-range flights, overflight of neutral nations, etc. Use of missiles could be equally problematic.[25] And, finally, there is the drawback of expense. For all but the richest nations, possessing advanced conventional weaponry is beyond their reach financially.

9. A CRITIQUE OF NUCLEAR DETERRENCE OF BW

Nuclear deterrence of BW can be and has been effective. When asked in December 1990 what the United States would do if Iraq were to use weapons of mass destruction, then Secretary of Defense Dick Cheney refused to rule out any type of US response. The possibility of US nuclear retaliation for nuclear, chemical, or biological attack was implicit.[26] In a January 1991 meeting with Foreign Minister Tariq Aziz, then Secretary of State Baker affirmed that any Iraqi use of weapons of mass destruction would be met with a drastic response. This was interpreted by Iraq as a promise of nuclear retaliation.[27]

There are at least two advantages to the declared nuclear-weapon states of relying on nuclear weapons as a deterrent against BW rather than in-kind retaliation. The first relates to the BTWC. To develop a BW deterrent, the BTWC

would have to be abrogated or violated, which would entail some political cost. The second advantage is that the effects of nuclear weapons can be controlled, more so than BW. The threat of nuclear retaliation for a BW attack also has several positive features over conventional retaliation. It can be swift and, relative to conventional force costs, inexpensive.[28] Loss of life by the country retaliating might be less with a nuclear response than with conventional deployments in theater.[29] Most importantly, nuclear reprisal is likely to be viewed by the BW aggressor as constituting an unacceptable consequence; thus, nuclear deterrence has a high potential for being very effective.[30] But, there are several difficulties with nuclear deterrence of BW. They will be discussed in terms of the declared nuclear-weapon states (using the example of the United States) and the non-nuclear-weapon states.

The declared nuclear-weapon states have given negative security assurances as part of their nuclear non-proliferation policies. That is, they have ruled out use of nuclear weapons against any nation that neither has nuclear weapons nor is allied with a nuclear-weapon state.[31] Interpreted literally, the assurance would mean that if a nation has BW and either threatens to use or actually uses them against the United States, for example, the United States would not retaliate with nuclear weapons. This policy obstacle to nuclear deterrence of BW could quickly be changed, however, if a crisis were to arise.

An important negative consequence of using nuclear weapons to deter BW is that it could promote proliferation of nuclear weapons, undermining the Nuclear Non-proliferation Treaty (NPT). Thus, if the declared nuclear- weapon states begin to rely on their nuclear arsenals to deter BW, other nations may also conclude that this is the best step to take. As mentioned earlier, however, a BW deterrent would be less expensive, easier, and more readily available than a nuclear deterrent.

A more important obstacle is that nuclear retaliation by the United States in the case of BW use is currently seen as politically unacceptable by much of the US public and certainly by President Clinton. Public perceptions are shaped by a number of variables. One is the notion that nuclear weapons represent an extreme weapon whose use in retaliation would be disproportional to any offense – other than a nuclear attack – that might have been committed. A related notion is that all nuclear weapons cause massive damage and radioactive fallout, just like the bombs dropped over Hiroshima and Nagasaki.

Public perceptions can change overnight, however. Imagine that a Middle Eastern country strikes a US ship in the Persian Gulf with BW, causing most aboard to die painful, gruesome deaths documented to the public on television. The US public could demand proportional retaliation. There would be at least four options. One is quickly reconstituting a US BW arsenal and responding in kind. This is unlikely for several reasons, including the fact that the United States would have to violate its international treaty obligations under the BTWC, as well as the fact that the victims of such a retaliation would include an uncontrollable number of civilians – something the United States tries to avoid.

A second option is massive conventional bombing. This would require air superiority and, in many instances, forward presence. Furthermore, it would not be proportional unless massive damage resulted – something which has been difficult to achieve with conventional bombs, and which might entail large numbers of civilian deaths. A third option is large-scale conventional attack, which would risk more troops being exposed to BW and has the faults outlined in the section above.

A fourth option, retaliation with nuclear weapons, might be preferred. An important consideration, however, is proportionality. US retaliation with a high-yield nuclear weapon that would destroy the enemy's capital and kill many civilians could be considered to be excessive, depending on the offense committed. However, use against known military targets of a very low-yield nuclear weapon, one which would cause very little release of radioactivity[32] and can be limited in the degree of destruction, might be viewed as more proportional. The use of one weapon of mass destruction would be met with retaliation using another type of weapon of mass destruction, albeit one with more limited effects.

Even if the US leadership were willing to use very low-yield nuclear weapons to deter BW attacks, a problem remains: US nuclear weapons are not very usable against nations other than those posing a strategic nuclear threat because the US arsenal consists mostly of weapons with yields above 5 kt. This arsenal was designed for two functions: war-fighting in Europe, and causing massive destruction in the Soviet Union. If nuclear weapons are to serve as a deterrent against BW attacks, the stockpile should include devices with a yields in the range of 10-1000 tons and should be deliverable against buried targets. Such weapons should be able to hold at risk high-value targets such as heavily reinforced underground bunkers as well as small-area (radius of approximately one-half km) battlefield targets. They should be deliverable via short and intermediate-range delivery systems. However, development of such weapons would probably require nuclear testing, which would be contrary to the current move toward a comprehensive test ban.

In summary, the US nuclear deterrent is not now effective vis-a-vis BW threats. US declaratory policy clearly excludes a nuclear response; there is limited public support for a nuclear role in such deterrence (based in large part on the misperception that nuclear weapons are necessarily high-yield and extremely damaging); and the US arsenal is not optimally configured to provide a range of proportional responses.

10. A CRITIQUE OF POSITIVE SECURITY ASSURANCES

A non-nuclear-weapon state which perceives itself as being threatened by BW has the alternative of developing its own deterrent or depending on other nations to protect and retaliate on its behalf. The latter option would be

preferable both from the standpoint of the nation itself (which would neither have to undergo the expense nor suffer political-military consequences of weapons development) as well as of arms control. However, to work, the alliance must be credible; the protected nation must believe two things: that the deterrent of the defender will be effective, and that the defender really will use the deterrent.

There are few nations capable of providing positive security assurances which would be credible in the face of BW threats. To be effective, as outlined above, the defender must have announced that it has BW and is willing to use it as in-kind retaliation (unlikely, given the BTWC), must have overwhelming conventional force that is seen as an effective deterrent (possible, but unlikely in many scenarios), or have a nuclear capability that it is willing to use to deter BW (which is hampered by the declared policies of all five declared nuclear-weapon states).

Even if there were a defender with a credible deterrent against BW, it would probably be hesitant to forge an alliance with many of the nations which most need protection. Iran provides a case in point. Assume that Iran has no BW deterrent of its own (which many not be the case). Iraq, which does have BW, could use or threaten to use it against Iran. Are there any other nations willing and able to ally with Iran and say to Iraq, 'If you use BW against Tehran we will retaliate massively against you'?

11. CONCLUSION

The ease with which countries or sub-national groups can manufacture and use biological agents as weapons is terrifying. It is therefore understandable why the international community is eager to apply arms-control declarations and inspections to help strengthen the existing ban on BW. Such measures are virtually guaranteed to fail, however, because BW production and storage can be so easily, cheaply, and successfully hidden. Given that the proposed confidence-building measures are unlikely to be effective in deterring cheating, even minimally, they are of little benefit. Also, they have a serious downside – the potential damage to bio-technology and pharmaceutical companies that would result from loss of proprietary information.

All types of deterrent forces – BW, conventional, and nuclear – are problematic. A deterrent that may work in one scenario may fail in another. Of the three, conventional deterrence is least likely to work against most BW threats. A BW deterrent, the easiest and least costly, would run counter to the BTWC, but is likely to be pursued by nations which perceive a BW threat but have no other deterrent capability. A nuclear deterrent, except in the case of the five declared nuclear-weapon states, would run counter to the NPT. For the declared nuclear-weapon states, use of nuclear weapons to deter BW attacks would require

revision of their negative security assurance policies. And, for the United States specifically, using nuclear weapons to deter BW would require reconfiguring the arsenal to provide a proportional response. Specifically, the option of responding with low-yield nuclear weapons would have to be developed.

NOTES AND REFERENCES

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1 The issue of non-state actors using BW, or state actors using clandestine and unattributed delivery, is also a serious problem. The question of how to deter or manage such threats is even more difficult than the issue of responding to state use of BW. This article focuses on the simpler, but still very difficult issue of state use of BW.

2 Vladimir Pasechnik, a senior biologist who defected to Britain in 1989, appeared on BBC's 'Newsnight' program and stated that Russian scientists cultivated bacteria in containers of Western antibiotics to make them resistant to treatment. See Bill Gertz, 'Russia Has Biological Weapons, Defector Says', *The Washington Times*, 22 January 1993, p. A9.

3 Measures other than arms control and deterrence have also been explored, but have not been deemed effective. Export controls have no true role in checking BW proliferation because the tools and materials are the same as those used in legitimate bio-medical research and are widely available. Positive incentives, such as assistance, may actually fuel proliferation. On this latter point, see Michael Moodie, 'Arms Control Programs and Biological Weapons' in Brad Roberts ed., *Biological Weapons: Weapons of the Future?* (Washington DC: Center for International and Strategic Studies, 1993) p. 50.

4 Effective verification is generally held to mean verification which would provide one significant confidence that cheating would be discovered.

5 See for example Edward J. Lacey, 'Deterring Biological Weapons: The Role of Arms Control' (Washington DC: US Arms Control and Disarmament Agency, 23 February 1995).

6 Graham S. Pearson, 'Prospects for Chemical and Biological Arms Control: The Web of Deterrence', *The Washington Quarterly*, Spring 1993, p. 151.

7 Jonathan B. Tucker, 'Strengthening the Biological Weapons Convention', *Arms Control Today*, April 1995, p. 12.

8 Because biological weapons can be produced in non-descript buildings, satellite photography would be of no use in identifying suspect sites. Although it is conceivable that there will someday be tools which would detect telltale biological effluent from a facility, for example, such technologies do not yet exist.

9 Pharmaceutical firms store samples of pathogens in a number of ways. For example, they may be placed in thin 10 cm. long straws and kept in cryogenic storage vessels containing up to 435,000 samples, each of which is identified by a number. It would be very simple secretly to code the samples intended for weapons purposes and place them amid samples intended for pharmaceutical research. Even if an inspection were to take the time to sort through all of the samples, the inspectors would not be able to identify the offensive sample as being for weapons. The planned use for the sample is a matter of intention, which is not something that can be identified by inspection.

10 Some organisms double in 20–30 minutes, so 2 liters could be made within 24 hours.

11 If manual methods of production were used, the equipment would consist primarily of glass flasks.

12 Purification need not be done at the same site as fermentation. If time were a critical factor due to an impending inspection, the product from the fermenters could be shipped off-site for purification and processing for weapons.

13 In a large facility, there are dozens of seals on each fermenter and there are hundreds of fermenters. Sampling the right seal on the right fermenter would be a matter of chance.

14 A. P. Zelicoff, 'The Biological Weapons Convention: What is the Role of Sample Collection in a Legally-Binding Regime?' *Politics and the Life Sciences*, vol. 14, pp. 79–84.

15 The US pharmaceutical and bio-technology industries have expressed similar concerns about the verification scheme proposed for the Chemical Weapons Convention. The US chemical industry, which has less to lose in such inspections, is also reticent regarding verification inspections, despite public statements to the contrary by a few chemical representatives. This author has spoken with many officials from both chemical and bio-technology companies who are adamantly opposed to arms control inspections of their plants.

16 There are thousands of facilities in the US pharmaceutical and bio-technology industries that would be subject to inspections. There are at least 500 BL3 facilities in the United States.

17 Al Holmberg, 'Industry Concerns Regarding Disclosure of Proprietary Information', *The Director's Series on Proliferation*, Lawrence Livermore National Laboratory, (UCRL-LR-114070-4), May 1994, p. 93.

18 A trial inspection conducted at a US company's pharmaceutical facility in December 1993 proved this point. Company officials, in cooperating with the inspectors (whose roles were played by US and UK government representatives), found that they revealed too much information piecemeal. At the end of the inspection, they felt that they had, in aggregate, revealed both process and throughput proprietary information. Were such information to fall into the hands of a competitor, the company almost certainly would have suffered severe losses.

19 This example was provided to the author by two US pharmaceutical industry representatives.

20 This information was provided to the author by officials from two different US pharmaceutical companies. A similar figure was cited by US Army officials as the cost associated with closing a base for inspection for one day.

21 Nikolai Burbyga, 'US, UK, Not Russia, Ready to Resume Bioweapons Production', *Izvestiya*, 5 April 1994, p. 2. The article implies that the US company has been used for BW agent manufacture and is being kept ready for future BW production. It states, 'At Pfizer's former plant for the production of biological weapons, manufacturing equipment formerly intended for the production of military-use biological compounds not only survives and is maintained in good working order, but is even being redesigned and modernized.'

22 Another option, chemical weapons, is not addressed here because it would entail many of the same pitfalls as conventional retaliation and is not viewed by this author as commensurate with BW, and therefore not highly effective as a deterrent.

23 The United States continues to believe that Russia has an offensive BW program. 'With regard to former Soviet biological weapons related facilities, some research and production facilities are being deactivated and many have taken severe personnel and funding cuts. However, some facilities, in addition to being engaged in legitimate activity, may be maintaining the capability to produce biological warfare agents. The Russian Federation's 1993 and 1994 BWC data declaration contained no new information and its 1992 declaration was incomplete and misleading in certain areas. With regard to the trilateral process that began in 1992, while there has been progress towards achieving the openness intended in the Joint Statement, the progress has not resolved

all U.S. concerns.' *US Arms Control & Disarmament Agency Report to Congress on Adherence to and Compliance with Arms Control Treaties*, 30 May 1995.

24 This has been pointed out by Brad Roberts in his chapter in Brad Roberts (ed.) *Biological Weapons: Weapons of the Future?*, p. 95.

25 For example, both the United States and Russia would hesitate to use strategic conventional missiles in regional conflicts for fear of causing the other to think that the missile, perhaps nuclear armed, was instead intended for it. And, both nations have few intermediate-range missile options due to their adherence to the Intermediate Nuclear Forces Treaty.

26 On 23 December 1990, Secretary Cheney said, 'Were Saddam Hussein foolish enough to use weapons of mass destruction, the US response would be absolutely overwhelming and it would be devastating.' *See US Department of Defense, Conduct of the Persian Gulf War: Final Report to Congress*, April 1992, Appendix Q, p. 2. The report further states that biological weapons pose a strategic threat to the US which '...will continue to require the full range of US deterrence and defense capabilities.' Also, General Schwartzkopf makes it clear in his book about the war that nuclear deterrence played a role vis-a-vis Saddam Hussein. See H. Norman Schwartzkopf, *It Doesn't Take A Hero* (New York: Bantam Books, 1992) pp. 389–390.

27 'UN Envoy: Iraqi Change Ended Crisis', *The Washington Times*, 30 August 1995, p. A10.

28 There has been recent publicity that the US nuclear arsenal cost billions of dollars, which is true when one lumps together the cost of the actual weapons as well as peripheral costs such as environmental cleanup. See Robert B. Barker, 'The Environmental Costs of the United States Nuclear Weapons Programme', in Kathleen C. Bailey (ed.) *Weapons of Mass Destruction: Costs Versus Benefits* (New Delhi: Manohar Publishers, 1994). If a smaller nuclear arsenal is the objective, and if enriched uranium is used instead of plutonium (the latter being more expensive to acquire and more costly to clean up after), the costs can be quite low. For example, South Africa's six-weapon stockpile is officially estimated to have cost only USD 200 million. See Waldo Stumpf, 'South Africa's Nuclear Weapons Programme', in Bailey, *Weapons of Mass Destruction*, pp. 75–76.

29 This assumes that the nuclear retaliation is against a country armed with BW, but having no nuclear counterforce. If the nuclear response were made against a country which also had nuclear weapons, it is likely that they would be used as well.

30 Nuclear weapons may be very effective against BW targets, in part because they may neutralize the biological agent. (This of course assumes that there is accurate intelligence regarding the location of the BW, which is by no means assured.)

31 This phrasing is based on the US negative security assurance. The statements by the other four declared nuclear-weapon states is similar. See Paul Bedard & Gus Constantine, 'US Vows No Nuke Attacks Against Non-Nuclear Nations', *The Washington Times*, 6 April 1995, p. A3.

32 For example, if a warhead with a yield of 10 tons were to be targeted against a buried bunker and detonated 15 m below ground, it would create a large crater with a diameter between 25 and 40 m, depending on geology. Fallout of 10 rad/hr would extend about 0.5 km downwind, and would cover about .06 sq km. Fallout of 1 rad/hr could extend as far as 1.2 km downwind from the blast but would cover less than 0.25 sq km. Radiation doses of 10–50 rad rarely cause radiation sickness, but there could be unpredictable long-term effects, such as increased incidence of cancer. The US Department of Energy's radiation limit for workers is 5 rem per year, equivalent to 5 rad per year from fallout. This example and the associated data on fallout are taken from Thomas W. Dowler & Joseph S. Howard, 'Stability in a Proliferated World', *Strategic Review*, Spring 1995, pp. 31–33.