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AIU MILITARY ASPECTS OF BIOLOGICAL WEAPONS

Research paper assignment for the Military Aspects of Biological Weapons Course

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1. INTRODUCTION

This paper will review the study of biological weapons (BW) from the perspective of military applications, defense and national security concerns, military technologies and strategies regarding the BW development, detection, and treatment of BW exposure-both battlefield and terrorist scenarios. Also, this paper will discuss advanced technologies such as use of cruise missile delivery systems and discuss the use of genetic engineering applied to the development of the next generation of biological weapons (aka Black Biology). Although much has been written on the history and kinds of BW, this paper will briefly survey these issues and focus more on the BW concerns of the military and in non-state sponsored attacks (e.g. terrorist) on civilian and military targets. This paper's content will include much from the United States (US) perspective, but it will include information or examples from other nations as well. It is worth noting that the premise that pervaded through out the research for this paper was not IF a BW attack would ever occur, but WHEN it occurs and how to effectively prevent or respond to such an attack (1, 30).

2. DEFINITIONS AND CONCEPTS

Couch defines a biological weapons attack as "the intentional use by the enemy, of live agent or toxins to cause death and disease among citizens, animals, and plants" (2). Daly states the five important attributes of a biological warfare agent are: High virulence coupled with high host specificity; high degree of controllability; lack of timely countermeasures to the attacked population; ability to camouflage the BW agent with relative ease; and high degree of resistance to adverse environmental forces (3). The variety of biological weapons includes bacterial (e.g. Anthrax, Q fever, Tularemia), viral (e.g. Smallpox, Hemorrhagic Fever, Venezuelan Equine Encephalitis), Fungal (e.g. *Coccidioides immitis*), or toxins (e.g. Ricin, Staphylococcal Enterotoxin B (SEB), or T-2 Mycotoxins) (4, 5, 6, 7, 8). Some weapons have been developed using arthropods as vectors (e.g. Yellow Fever, Plague, or Dengue Fever (9). For example, some reports of BW by the Japanese during World War II (WW II) included the dispersal of plague infected fleas by air to infect villages in China (10).

Furthermore, new agents of BW have been described as bioregulators. Bioregulators are a diverse set of compounds used to manage a wide variety of physiological processes (i.e. homeostasis), including immune responses, heart rate, blood pressure, temperature, bronchial

and vascular tone, muscle contractions, as well as blood chemistry, and consciousness. If these compounds were used in an aerosol or oral route, they could be used by bioterrorists to trigger such reactions as fever, hypoglycemia, shock, disseminated intravascular coagulation, mood alteration, stroke, cardiac failure, arterial thrombosis, or death (11).

Finally, BW can be directed against agricultural targets using various bacterial, viral, and fungal agents (e.g. Anthrax, Foot-And Mouth Disease, Wheat Smut) (12, 13). The reasoning for targeting agriculture is that American agricultural products are a key component of the US national infrastructure which besides including food production, it is the number one contributor to the US trade balance of payments (12). Therefore, attacking the agricultural sector could weaken a nation both internally as well as economically in the global market place.

In the delivery of BW agents, weapon delivery systems had evolved tremendously in the 20th Century. Prior to the 20th century and the development of germ theory, the BW methods were crude and based only on the concept of contagion. The Romans, Greeks, and Persians used corpses of animals to pollute water supplies of their enemies. Even in 1863, Confederate General Johnson used corpses of sheep and pigs to pollute the drinking water at Vicksburg (14).

Yet, in the 20th Century, with the identification and isolation of pathogens as well as the techniques to culture the agents, BW munitions (Biomunitions) were developed to disseminate BW agents (4). Biomunitions were either strategic or tactical and their application depended on the following factors: strategic or tactical value, causalities, flexible results, large or small area of coverage, no physical destruction, and cost (4). Most agents were dispersed in the air (aerosol), but even airborne agents had differing effectiveness due to the mode of agent dispersal (dry particle versus wet particle), meteorological conditions (dry air versus rainy weather), temperature (cool evening air versus hot daytime air), daytime or nighttime use (e.g. ultraviolet rays from sunlight would inactivate many agents rather quickly), and number of live cells necessary to cause infection. The United States (US) biomunitions program included spherical bomblets (M-143), spray tanks (A/B45Y-3), and aerosol bombs (M114 and M33) (4, 20). It is worth mentioning that during the era of the Soviet Union, small bomblets were loaded into Intercontinental Ballistic Missiles (ICBM) like the SS-18, which contained a variety of BW agents and would release five or six BW agents on US population centers during the 1980's (these agents included Anthrax, Smallpox, Plague, and Ebola) (15, 16, 17).

It must be noted that since the early years of the BW offensive program, BW was considered a strategic weapon as it was less expensive than Chemical Warfare (CW) or Nuclear Weapons. For example: to kill the same number of personnel with BW costs about $2 compared to $2000 for chemical weapons, and $2,000,000 for nuclear weapons (4). As techniques for controlling the decay factors of the agents (biological, physical, dispersion) as well as decontamination and prophylactics became better understood, BW became accepted as a tactical weapon as well.

Most applications of BW were used to kill personnel, yet this depended on whether the BW agent had a high or low mortality rate as well as whether the enemy forces were vaccinated or had another means of protection from the BW agent. For example, the selection of a BW agent as an incapacitation agent might be favored over lethality. Incapacitation of forces maybe favored in some situations where the affected personnel create a greater drain on the medical and evacuation infrastructure as well as create the expected panic in the general population. Low doses of SEB toxin as well as the diseases Q fever, Venezuelan Equine Encephalitis, and Rift Valley Fever have high morbidity rates (60 to 90 %), but very low mortality rates (less than 1%) and hence would be prime BW candidates for incapacitation goals (2, 4). BW agents with very high mortality rates include Plague (if untreated, pneumonic is 100%), smallpox (30%+ or using the vaccine-resistant strain "ARALSK" 100%), and Anthrax (75%-100%) (4, 17, 18, 19).

As for BW applications on enemy forces, preparation may be the difference between being combat ready versus losing the battle even before it starts. Just prior to the US led invasion during the Gulf War of 1991, Iraqi forces had been able to cultivate anthrax and had equipped a Mirage jet with a spray tank capable of dispensing lethal anthrax over coalition troops. After the war, the Office of the Secretary of Defense (OSD) commissioned a study of what would have been the potential threat of an anthrax attack on US and coalition forces at the start of ground action. On day one of the ground action, the coalition had assembled half a million military personnel for the attack and 320,000 were assembled along an area of the coastline southeast of Kuwait City. The OSD report states that if the Mirage was ordered to fly by Saddam Hussein and dispersed anthrax upwind from the 320,000 ground forces, then an estimated 76,300 of the 320,000 would have died of anthrax (1). It must be noted that the OSD report also stated that IF all of the 320,000 forces were vaccinated against anthrax, then 122 deaths might have resulted (15).

3. STRATEGIES AND CONSIDERATIONS

A. BW AND CONCEPTS OF WAR

In any war, there are different decision making levels or concepts of the war. The different levels are strategic, operational, and tactical. The Strategic level involves actions and issues of the national interest (e.g. Cold War policy of containment designed by the Pentagon and Joint Chiefs of Staff). The Operational level involves actions and issues of a regional command (e.g. US air and naval bases in Japan as part of Pacific Command). The Tactical level involves actions and issues important to forces engaged on the battlefield (e.g. a column of tanks advancing into Bagdad during Operation Iraqi Freedom or movement of a Special Forces unit on a mountain slope in Kandahar Province, Afghanistan). The Strategic level sets the national policy (given by the Grand Strategic policy set forth by the president in consultation with the Intelligence, Military chiefs, etc.), but it is the Operational level that sets the tactics necessary (and hence provides the planning and resources for the tactics) to achieve the Strategic goals (21, 22, 23, 24).

BW has been considered in military terms, a "force multiplier" (a tactic or material that can seriously improve one's position on the battlefield) (26). However, BW has differing effects depending on which level of war the BW is applied. Part of the differing effects depend on the above mentioned points: weather, particle dispersal, cost, pathogen mortality rates, number of cells or toxin dosage required to affect enemy personnel, daytime or nighttime application, area of coverage desired, as well as whether the enemy has warning or prophylactic defense against the BW agent. Furthermore, due to the time factor required from exposure to the pathogens to the development of infection which renders the soldier or civilian febrile or unconscious; BW agents may take up to 14 to even 21 days (e.g. Q fever 14 to 21 days; anthrax 1 to 7 days); whereas it is important to note that BW toxins are effective in a shorter time period (Botulism toxin 12- 48 hours, SEB 1 to 6 hours) (4). Thus, chemical warfare agents and nuclear weapons (although more costly to produce and store) are considered more effective against unprotected troops in both a tactical as well as strategic level.

BW becomes useful if the immediate goal does not require immediate death of enemy or vaporization of a city or military installation (25). BW becomes very effective if the goal is to attack strategic or operational centers: industrial cities, military bases, naval ports, government

centers, or population centers. BW success would be determined by number of deaths over a short period of time; the taxing and possible collapse of medical and government services; degradation of military readiness; and exhaustion of personnel necessary to maintain national defense or critical national infrastructure. BW would also be effective against troops massing on a border prior to an invasion. It is interesting to note that Soviet Defense Ministry built BW into their military planning to be used not merely for weapons of last resort, but even as conventional (aka nonnuclear) conflicts to attack Strategic and Operational level sites such as population centers, enemy troop reserves, shipping ports, and rail centers (25, 26). In 1989 Ken Alibek, the former first deputy chief of the Biopreparat system (Soviet BW program) was told by a senior military officer that in one attack (some time between 1982 and 1984) by Soviet forces, glanders was used against mujaheddin forces in Afghanistan. The use of glanders (*Burkholderia mallei*) as a BW would have a fatal effect on the mujaheddin transport animals used to manage the mountainous countryside; but it would also lead to fatalities amongst resistance fighters as well-70% mortality (4). This is a clear example of BW applied as a tactical weapon (16).

Finally, BW has long been considered a tool for use in "asymmetric warfare" (27). Asymmetric warfare is the application of less technological, unconventional weapons, tactics, and strategies. Many times this term had been connected with guerilla warfare, but more recently the term has been used to refer to cyberwarfare and Weapons of Mass Destruction (WMD)-which includes BW! (27). Thus, non-state agents or rouge nations would be attracted to the use of BW to achieve an advantage over other nations, military forces, or civilian targets.

B. BW AS THE "POOR MAN'S A-BOMB"

BW has long been referred to as the "Poor Man's A-Bomb" (15, 25). The advantages for a nation to develop BW weapons are that they are less costly to develop, produce, and store than chemical weapons or nuclear weapons. Many technologies used in the production of making BW agents are the same technologies of fermentation, cell culture, bioprocessing, lyophilization, and milling that are used to make beer, pharmaceuticals, vaccines, and commercial or industrial enzyme products (15, 25). This problem of "Dual-Use" Technologies (i.e. technologies that can be applied for non-military commercial OR military weapons development) makes it difficult to determine if a nation or even an individual is making a BW agent unless actually discovered at the time of BW production. These common production

techniques also means that the equipment involved with BW manufacture is very inexpensive (as compared to technologies to develop Chemical Warfare agents or Nuclear weapons). It has been calculated that to obtain the same lethal effect of a nuclear weapon as compared to a BW weapon, one would have to invest $800 for every dollar invested in BW (15).

Also, BW infects damage silently; as opposed to the blast of a nuclear bomb! BW does not need a bomb to disperse the agent. Rather, an aerosol mist of BW agent can be released by airplane crop duster, spray tank on a jet, liquid culture poured into a water source, or even sprayed as a cloud from an off shore ship (note: wind shifts would drive the BW agent inland). Due to the time delay before a disease outbreak is noticed, BW can provide "plausible deniability" to any nation or even terrorist group that chooses to use BW, but then remain silent. Finally, a BW agent could be used to tie up national resources managing the outbreak while the enemy forces then prepare to invade the affected nation; the BW outbreak would hamper military forces trying to stage a counterstrike to the invasion (15).

C. THE CHALLENGES OF BW PROLIFERATION

BW proliferation is the spreading of BW technology, expertise, or even pathogens to other nations or non-state groups (i.e. terrorists). Although many nations are signatories and have ratified the Biological Weapons Convention (BWC) (aka Biological and Toxin Weapons Convention of 1972), many nations are still suspected or have been found to be developing BW. These nations include North Korea, Syria, China, Iran, Libya, Russia, Taiwan, Israel, and Egypt (28, 29).

One challenge to preventing other nations from developing BW technology is controlling "technology transfer". "Technology Transfer" is the deliberate exchange of technology from one nation to another (or from one nation to a non-state group such as terrorists). Usually the transfer of technology can be through the sale of equipment, blueprints, or even the exchange or emigration of technically knowledgeable personnel who have expertise in that particular technology. After the fall of the Soviet Union, much concern arose over the unemployment of thousands of BW scientists and technicians and whether they would be recruited by other nations to build up their own BW program and expand their BW arsenals. The US provided funding for former BW scientists to develop other commercial products in Russia (e.g. vaccines, pharmaceuticals) as well as other funding to allow former BW scientists to emigrate to the US to

work at universities, biotechnology and pharmaceutical firms (27). Unfortunately, other nations such as Iran have hired Russian, Chinese, and North Korean scientists to bolster their BW development (28).

As previously mentioned, one other challenge to BW proliferation is the "Dual Use" technology dilemma. Much of the present day equipment for biotechnology, food fermentation, and pharmaceutical manufacture can be used for the production of commercially valuable products (e.g. beer, vaccines, antibiotics, cytokines, enzymes, etc.) as well as the production of bacteria, viruses, and toxins. Furthermore, the same molecular biology lab equipment used to explore recombinant DNA research could be also used to create genetically engineered pathogens for the next generation BW (27). The problem of "Dual Use" technology is that a perpetrator nation (or terrorist organization) can deny BW development to disarmament inspectors (15). Also, the global availability of this equipment and training for the equipment makes the development of BW inexpensive and the availability of trained personal easy to obtain. Thus, BW can provide even lesser developed nations and/or organizations with limited funds a means to obtain a "level playing field" against Superpower nations with a modest investment in equipment and manpower (15).

D. BW AND TERRORIST APPLICATIONS

Terrorist BW applications has heightened the awareness of BW in the military as well as government resolve to deal with terrorist based BW (aka bioterrorism). Several incidents have fueled military discussion of biodefense readiness. In April 1990, two attacks by the doomsday cult Aum Shinrikyo, were directed against US personnel based at the Yokohama Naval base in Japan. Both attacks failed, yet due only to the inability to the cult to properly weaponize the botulinum toxin (1, 30). In the fall 2001, the US Senate and other government offices were attacked through the mail with weaponized (i.e. aerosol particles milled to the 1 to 5 micron size for effective intake into the alveoli of the lungs) anthrax spores (30). In 1984, the Bhagwan Shree Rajneesh cult located in Antelope, Oregon, contaminated ten restaurant salad bars with Salmonella bacteria, resulting in at least 750 local citizens sickened (30).

It should be noted that the key motivation for terrorists to obtain and use BW is to inflict causalities, spread terror to the populace, and to weaken the enemy's will to fight (32). Bullock notes seven key characteristics that make BW an ideal weapon for terrorists and rogue nations:

ease and low cost of production; ease of dissemination as aerosols; efficient exposure of great numbers of people through inhalation; delayed effect; high potency; high subsequent mortality and morbidity; and, the ability to wreak psychological havoc (31). One other important observation is that terrorists could work with enemy nations to "soften up" the target nation by inflicting a BW attack on a large population or military complex. As causalities start to build up along with quarantines and evacuations, the regional public infrastructure would collapse and the military would be required to maintain order (as well as treat their own BW causalities). Once the combat readiness of the military has been weakened by the domestic BW attack, rendering borders or bases vulnerable; an opposing military could confidently invade with reduced or little resistance (15, 31).

4. BRIEF HISTORICAL EXAMPLES

As this paper has demonstrated, the application of BW in military conflicts goes back centuries. In 1346, during the siege of Kaffa (now Feodosia on the Crimean coast), Mongols catapulted plague infected cadavers into the fortified city and plague spread throughout the city. It is easy to comprehend the outbreak since plague bacteria can enter cuts and abrasions on the hands, while city dwellers removed the cadavers and/or body fluids from the city streets for example. Even though the Mongols did not understand Germ Theory, they understood the concept of contagion. Hence, using the contagion from the cadavers to achieve the spread of plague inside the city, the Mongols achieved the fall of Kaffa and the evacuation of its Genoese merchants (33).

Smallpox was another disease used in early forms of BW in the 1700's. In 1763, during the Pontiac Rebellion (aka Indian Wars), the British were struggling to maintain their major outpost at Fort Pitt, (located in western Pennsylvania) under siege by Indian attacks (33). Although various historical accounts are conflicting, Sir Jeffrey Amherst gave the orders to Colonel Henry Bouquet (who was heading to Fort Pitt with reinforcements) to infect smallpox on the Indian population using infected blankets. Bouquet upon arrival at the fort, gave two blankets and a handkerchief to hostile chiefs (14). Although various scholars debate whether the infected cloths contributed to the spread of smallpox (14, 33), it was known that the pus exudates of smallpox can contain active smallpox virus and hence spread the disease. Furthermore, Native American Indians were very susceptible to smallpox and mortality rates were high as

smallpox was a disease imported to North America via the European settlers (34). Within months after Bouquet's arrival, the siege of Fort Pitt ended.

During the American Revolutionary War, the use of smallpox was a powerful BW tool. British troops were vaccinated (via variolation), whereas American colonists were not. During the siege of Boston to remove encamped British forces, smallpox broke out in the city in December 1775. British General William Howe ordered all British troops variolated and then variolated civilian refugees in hopes of spreading the disease to susceptible Colonial forces outside of the city. General Washington upon hearing the news of the smallpox epidemic, delayed the liberation of Boston, and unfortunately his troops suffered from the smallpox outbreak (34).

During the siege of Quebec City in December 1775, Continental forces under Benedict Arnold were poised to seize the fortress city. The British fort commander had civilians variolated and then had them mingle with Continental troops. With a few weeks, a severe smallpox epidemic broke out affecting nearly half of the ten thousand Continental troops. After burying the dead, The American forces retreated in disarray to Fort Ticonderoga (33, 34). As a result, of repeated smallpox outbreaks amongst Colonial troops, General George Washington- himself scarred by smallpox at nineteen, ordered in 1777 the entire Continental army variolated before he launched any new military operations (34).

During World War I (WWI), Germany's military command thought it was barbaric to use BW against soldiers, yet conducted an active campaign of BW using anthrax and glanders to infect military draft, cavalry, and livestock (e.g. horses, mules, cattle) (14, 35, 36). These BW attacks occurred in Bucharest and Mesopotamia as well as within neutral nations supplying military animal stocks to Allied forces (e.g. US). One of the best known BW agents was the American-born, German heritage physician, Anton Dilger. Dilger recruited by the German military command, worked out his of Chevy Chase, MD basement producing BW cultures of Glanders and Anthrax which were used to infect mules and horses intended for export to Allied forces in Europe (35, 36).

By the time WWII began, many countries began or had active BW programs. Although Adolph Hitler was against using offensive BW for fear of Allied retaliation using their own BW, Nazi Germany had a limited BW offensive program in development, but never used any of their products. It is interesting to note that during WWII, Germany produced defensive BW such as

vaccines and sera against plague weapons from the Soviet Union as well as a variety of anti-crop and anti-animal BW weapons including potato beetles, blight, choking weeds, and Foot-and-Mouth Disease (37). During WWII, Britain, US, Canada, and all had active BW offensive programs and shared information and research amongst each others programs, but no offensive BW was used against any of the Axis Powers (14, 26). The USSR BW program was active and the Soviets were believed to have used unsuccessfully Tularemia against the German invasion (4, 16). As previously mentioned, Japan was one of the few nations during WWII to have an active BW program and to have used BW against Chinese civilians and tested BW weapons against live prisoners (10).

5. BW TREATIES

Before WWI, a variety of international agreements and codes of conduct existed that prohibited the use of poisons or so-called "poisoned weapons". These include the Strasbourg Agreement between France and Germany (1675), the Lieber Code of the US Army (1863), and the Hague Peace Conventions of 1899 and 1907 (these last two included prohibitions against the use of infected carcasses to poison wells (38). Yet, even the Greeks and Romans condemned the use of poison weapons in war as a violation of the "law of nations" and around 500 BC, the Manu Law of India forbid poison weapons considering them "inhumane" (39).

Yet, after WWI and the extensive use of Chemical Weapons, the League of Nations began a process to ban chemical weapons. After several commissions were assembled to debate and review the issues of chemical and bacteriological disarmament, it was the Polish delegates to the League of Nations that proposed and promoted inclusion of bacteriological weapons in the treaty that came to be known as the "1925 Geneva Conference" (later called the Geneva Protocol) . The most noted speech on inclusion of banning bacteriological weapons in the Conference was General Kazimierz Sosnkowski, who explained that bacteriological weapons could be easily hidden, could easily lead to mass extermination of "men, animals, and plants", as well as easily lead to epidemics (38). Although between 1925 and 1939 most of the major powers ratified the Geneva Protocol, the US and Japan did not (38). Some nations did not consider BW was a viable tool of warfare (26). Also, the USSR and Japan continued extensive offensive BW research and preparations during this period (26).

After WWII, the arms race between the US and Soviet Union expanded beyond nuclear and chemical weapons and also included extensive research and development of BW-both pathogenic agents as well as manufacturing and delivery systems (16, 40).

On November 25, 1969, US President Richard Nixon surprised the world by announcing the unilateral abolition of BW (40). Privately, in response to inquiries by the Secretary of Defense Melvin Laird, Nixon told him that any nation that used BW on the US, "we'll nuke 'em" (40). Within one year, the Soviet Union accepted the opportunity to develop a BW disarmament treaty. The Biological and Toxin Weapons Convention (BWC), signed in April 1972, was the first multilateral treaty in recent history to ban an entire category of weapons. The BWC was ratified by many major powers (including the US, Great Britain, France, and USSR) and went into effect in 1975. The treaty states that all biological weapons and delivery systems are to be destroyed and only defense research is permitted. Also, any nation can report to the United States of another nation that is cheating on the BWC. Finally, one provision of the treaty requires member states to assemble for a review conference (also called Confidence Building Measures) to review the status of the treaty and work on any scientific or technological developments that may have arisen (40, 41).

Unfortunately, even in 1975, nations began to cheat on the BWC treaty. The most notable violators to the BWC are the Soviet Union (Biopreparat program), South Africa (Project Coast) (42), North Korea, and Iraq (16, 39, 40, 42). Shoham and Wolfson (17) present evidence in 2004, that despite Russian assurances and the BW declaration by former President Yeltsin in 1992, the Russian military is still a threat as it still possesses stockpiles of BW as well as BW production capabilities (25). Furthermore, despite BWC confidence building measures and discussions on trying to prevent terrorists from obtaining BW (41, 43), there are at present greater concerns that rogue nations or terrorists will obtain BW technology and use it. These concerns are fueled by CIA evidence of Russia assistance to North Korea in the development of advanced anthrax BW, including ultraviolet (UV) light resistant forms (40); Russian scientific assistance to Iran in the development of biotechnology and BW (26, 44); Al Qaeda's interest and efforts in development of BW and other WMD (13, 45). Evidence of Al Qaeda's BW interest includes BW production documents secured from training facilities in Afghanistan (13) as well as a senior bin Laden associate who in 1999 while on trail in Egypt, declared that Al Qaeda had BW as well as chemical weapons (2).

6. PRESENT POLICIES AND METHODS OF DEFENSE AND DETERRENCE

Ainscough presents one remarkable quote: "the First World War was chemical; the Second World War was nuclear; and that the third World War-God forbid-will be biological." (27). Davis (30) presents a wake up call by attacking the prevalent myths of BW. These six myths are: absence of a significant BW attack; the US has never been attacked by a BW agent; BW requires very intelligent, very educated, and highly funded program to produce, weaponize, and employ a BW agent; BW must be too difficult as previous attempts have failed; there are moral restraints that have kept BW from being used; and the long incubation period required for BW make it useless to users. Many of these arguments have been dashed to the ground by the September 2001 attack on the US by Al Qaeda (e.g. flying airplanes into buildings) and the subsequent anthrax attack via mailings to targeted Senators and others. We must confront the reality that there are some groups or individuals willing to die to achieve their goal of terror on an innocent population. Yet, history will remind us that the Aum Shinrikyo and Bhagwan Shree Rajneesh used BW in their attacks. Furthermore, the Germans used BW against animals in WWI, the Japanese used BW in WWII, and the British used BW in 1763 and during the American Revolutionary War. Also, we can not forget the strategy of poisoning drinking water using dead animals in the US Civil War or farther back to the time of the Greeks and Romans. Finally, we are compelled to recognize that any treaty (e.g. Geneva Protocol of 1925 or BWC) is merely ink on paper to those who choose to cheat on any treaty (e.g. USSR, Iraq, South Africa) or are non-state entities and never agree to a treaty (Al Qaeda or Aum Shinrikyo). Therefore, we must confront strategies of BW defense and deterrence.

Deterrence against BW is difficult to understand unless one considers what would be the response by the government subject to the BW attack and now dealing with personnel ill or dead due to the BW attack. To return to the "nuke 'em" quote by President Richard Nixon, Lebeda discusses this deterrence strategy in light of diplomatic exchanges between the US and Iraq prior to the Gulf War of 1991 (aka Operation Desert Storm). President George H. W. Bush and other high level US officials made it clear that a severe response would occur if Iraq used BW (or Chemical Weapons) against Coalition forces (50). Iraqi officials read this to be a form of "escalatory deterrence" (i.e. use of nuclear weapons) (50). Lebeda notes that "to deter" means to convince the enemy that the cost of aggression exceeds any possible gain. The author discusses this concept in a variety of actions: Military, Diplomatic, and Defensive. Briefly, the

deterrence by military action always leaves the US with the option of retaliation using nuclear weapons. Also, Lebeda notes that "Retaliation in kind", such as the US retaliating with chemical or biological weapons tends to confuse the political arena and confound efforts to develop new international treaties to control WMD proliferation and production. Deterrence by diplomatic action returns to the BWC and Geneva Protocol of 1925 to maintain political and diplomatic pressure against nations possessing BW. Also, in the diplomatic arena, inspections and verification efforts can be required with which the results are reported to the United Nations. Deterrence by defensive action serves as the final leg of the triad that builds up a web of deterrence. Defensive action plays a key role in developing medical (drugs, antibiotics, vaccines, diagnostic tests) and nonmedical countermeasures (masks, detectors, protective over garments, and shelters) which deny the adversary the maximum benefit from BW. In essence, if the BW agent will not create the high number of casualties, then it is not worth the expense to develop; not worth the chance it might return back and create a local epidemic; and not worth the chance that the enemy will retaliate with more powerful weapons (50).

Furthermore, the defense against any BW attack must include Human Intelligence (HUMINT) as BW can be made or transported in small facilities or hidden from spy satellite view via underground facilities (44). It is the intelligence agent observing the bioreactor making anthrax, or the BW filled SCUD, or the dispersal of BW into a reservoir or a water tank that can make the difference in locating and connecting the BW attack with the perpetrators. Thus, the knowledge to connect the adversary making, storing, or releasing BW may require improvements in HUMINT.

In a situation of BW release, whether on a battlefield or a bioterrorist attack on civilians, one level of protection for military personnel that is essential is the means to prevent inhalation of the BW agent or prevent the agent of coming in contact with skin, mucous membranes, or the eyes. This is especially important for toxins such as T2 mycotoxins which can be absorbed by skin, whereas skin abrasions can permit the entry of various pathogens like anthrax, plague, smallpox, or Ebola. During the history of the US BW program, various masks were developed. The present day mask, the M40, has a molded silicone face piece, with a voice mitter, drinking tube, as well as filter canister mounts. The mask filter (US C-2 canister) acts to filter particles from the air via an activated carbon filter as well as an electrostatic filter. Also, other protective garments include: battle dress over garment (used once for a 24 hour period and upon

contamination, it is burned), chemical protective undergarment (used for protection against chemical warfare agents), vinyl rubber over boots (worn over the standard military boot) and vinyl rubber gloves. The Military Operations Protective Posture (MOPP) conditions are levels under which part of the protective garments or all garments are worn-depending on the hot weather or type of agent present. For example: MOPP-4, all garments and mask are worn; MOPP-0 all garments and mask carried or available, but not worn (2, 4).

After the agent has been released, detection of the agent is necessary, especially since signs of illness may take up to 14 days after the initial exposure to the BW agent. A variety of monitoring and detection devices exist in the US military. The Long Range Biological Stand-off Detector System (LRBSDS) uses an infrared laser to provide an early warning of an aerosol cloud at a distance of up to 18 miles. The Biological Integrated Detection System (BIDS) is a vehicle mounted portable lab that samples aerosol particles and subjects them to a variety of genetic and antibody-based tests to identify the BW agent present. Both devises are being fielded by the military and can be adapted for first-responder civilian applications (2).

Recent advances in nucleic acid chemistry and genetic amplification technology has heralded more extensive and quicker tests for a variety of BW agents. Many are based on Polymerase Chain Reaction (PCR) techniques as well as DNA binding probes with fluorescent dyes that bind to specific sequences of the unique BW agents (46). Yet, many of these diagnostics must withstand the demands of field use: that is, must be portable, rugged, and rapid in detection and analysis. The Ruggedized Advanced Pathogen Identification Device (RAPID) has the advances of being able to withstand field requirements and at the same time uses a composite capillary tube to provide two forms of pathogen detection protocols: screen tests to analyze samples for the presence of multiple different organisms simultaneously, AND provide batch tests to analyze multiple samples for a single organism (46). Henchal et al notes that since no one test will be able to identify all BW agents, a diagnostic system that combines clinical diagnosis and medical intelligence with immunodiagnostic tests, rapid gene amplification assays (e.g. RAPID), and standard microbiological tests (e.g. microbial cultures) will provide results with the highest quality and greatest confidence in BW detection and diagnostics. If these techniques are distributed throughout a network of military and civilian laboratories, then rapid detection of BW agents after a BW attack would be assured as will the rapid treatment of BW victims (47).

Culpepper and Pratt (48) note that advances in medical BW defense will require improvements in vaccine technology to provide more immunization defenses against BW agents. These advances will be required to cover several pathogens at the same vaccination as well as provide defense against genetically engineered BW agents (more on BLACK BIOLOGY below). Although there is some success with the Anthrax and Smallpox vaccine, other BW pathogens (e.g. Ebola, Ricin, or Brucellosis) do not at present exist (5, 49). These next generation vaccines will be constructed using Naked DNA, Chimeric Antigens, Synthetic Peptide based, or RNA replicons from alpha virus platforms (48). The authors state that the defense research program will create conditions where the aggressor might be less inclined to use the BW agent in the battlefield; especially since most of the military forces are immune to the BW pathogen (48).

Although an array of antibiotic drugs exist today, only some select ones are effective for a specific BW agent (e.g. doxycycline or ciprofloxacin for anthrax). The challenge to BW antibiotic therapeutics is developing antibiotics or antivirals that are effective against BW agents. This will be further complicated by genetically engineered BW agents that are resistant to many antibiotics (3-more on Black Biology below). Alibek suggested the development of non-specific immune modulators that would stimulate the innate immune defenses for any BW agent (16). Some progress was reported by Cerys Rees et al, using synthetic cytosine and guanosine (CpG) DNA as a generic therapy against infectious diseases (51). Although this research is early in the program, it is hoped that various CpG sequences can promote and/or activate macrophages, monocytes, dendritic cells, NK cells, and the complement system to overcome various BW agents (51).

Finally, BW defense specialists must have a criterion to differentiate whether an infectious disease is a natural epidemic or a BW attack. Noah et al (52) discusses the epidemiological distinctions by focusing on a questionnaire that examines the epidemiological data of the disease, location of the outbreak, temporal patterns of the disease, number of cases, unusual strain or variant of the pathogen, morbidity/mortality rates, previous history of an endemic outbreak of the disease, seasonal distribution, antimicrobial resistance patterns, zoonotic potential, as well as the proportion of combatants among the population at risk. In examining these factors, a BW trained physician can make a determination whether the disease outbreak heralds from a BW attack or a natural epidemic (52).

Also, since many first symptoms of BW agents are similar, how do physicians differentiate the illnesses to speed up treatment and reduce patient mortality? Wiener (53) describes a strategy of asking questions to determine the BW agent, the analysis of symptoms to identify the specific pathogen against other possible pathogens, what personnel are vulnerable, as well as what countermeasures are possible. Again, this is part of BW deterrence since the means to quickly ascertain whether a BW attack has occurs (versus a natural outbreak of an unusual pathogen), diagnose the best possible treatment and determine what other countermeasures (e.g. masks, MOPP-4, vaccination, antibiotics) are necessary to prevent further morbidity or mortality (53).

7. PRESENT THREAT

Davis paraphrases a threat determination formula devised by Lt. Col. Don Noah, USAF (54). The threat of BW can be quantified by integrating the following variables: An adversary's *intent* to use BW; an adversary's *capability* to use BW; our own *vulnerability* to BW.

In essence:
Enemy Intent + Enemy Capability + US/Allied Vulnerability = Threat (54)

The present threat is very real as the US is still slow in the development of the necessary vaccines and drugs to deal with some BW agents (5, 39). Furthermore, even with treaties meant to stop BW weapons development, nations have been cheating and other nations or terrorists have been trying to develop BW (2, 13, 16, 39, 40, 42). Also, the problem of technology transfer arises, when the same technology used to make vaccines or drugs can be used to cultivate BW agents. Finally, due to the dilemma of "dual-use" technology, the equipment to make BW agents is inexpensive and openly available on the global marketplace. Kathleen C. Bailey, former assistant director of the US Arms Control and Disarmament Agency, stated that she is convinced that a major biological arsenal could be built with $10,000 worth of biotechnology equipment in a room 15 feet by 15 feet (39). Finally, the application of BW agents as aerosols is quite easy and can require a modern spray unit attached to any airplane. Al Qaeda operatives generated a lot of fear when it was reported in the news that the operatives had explored renting crop dusting aircraft (30). The news media reported that a BW attack might occur.

But beyond aerosol attacks, BW attacks can come from other directions. Hickman examined the vulnerability of water systems (both military and civilian) to BW attack. In his analysis he identifies critical points which if left vulnerable, could be targets for BW or chemical weapons (CW) and thus render USAF operations-which depend on that water- neutralized or dead. Hickman proposes several steps to improve force protection of these critical water supplies, including: focus on water system vulnerability assessment, review of Civil Engineering water system outsourcing and management practices, and re-evaluation of the CW and BW conventional wisdom of threat and risks. Hickman is not unusual in examining the BW threat to water systems. Project Coast in South Africa used the BW agent cholera s in river water supplies to attack forces opposed to white South African rule (40).

Furthermore, BW have been developed against agricultural targets, both crops and animals. The threat to a nation's economy would be great if BW was directed at the agricultural products that a nation produces (12). According to Wilson et al, potential targets of agricultural BW would include: farm animals (including livestock, poultry, and fish), field crops (including grains, trees, fruits, and vegetables), processed food, and agricultural storage facilities. During the 20th Century a variety of plant pathogens were developed for agricultural BW, including ergot, wheat rust, rice rust, and potato blight. But Wilson also describes how various animal based agricultural BW agents including glanders and anthrax were used with varying success in the 20th Century. Wilson finally warns that four key pathogens are prime for BW attacks against agriculture. These include: Foot-and-Mouth Disease, Avian Influenza, Classic Swine Fever (aka Hog Cholera), and Newcastle Disease. Wilson concludes with a call for vigilance using an intelligence and surveillance system that is responsive to animal disease and the needs of agriculture (12).

Peterson (13) discusses the problems with agroterrorism using Foot-and-Mouth Disease (FMD). If FMD was distributed in the US by terrorists as a BW agent, Peterson states that Americans could expect an immediate and sustained increase in the price of food as well as an economic catastrophe due to need to destroy vast numbers of infected cattle (13). Peterson's recommendations include getting lawmakers to change the definition of "Weapons of Mass Destruction", (title 50, chapter 40) in the US Code on the Defense against Weapons of Mass Destruction Act to include agricultural diseases, not merely just human diseases. Furthermore, Peterson recommends that the US Department of Agriculture (USDA) build up their

infrastructure with state agricultural agencies and that Homeland Security and the Department of Defense provide help to the USDA Animal and Plant Health Inspection Service (APHIS) to deal with future agroterrorism attacks (13).

8. FUTURE THREATS DUE TO TECHNOLOGICAL DEVELOPMENTS

A. BIOCRUISE DELIVERY

With the development of new technologies such as cruise missiles, new threats involving BW will arise on the horizon. Biocruise is defined as the combining of BW technology with cruise missile delivery systems. A cruise missile is defined as "an unmanned self-propelled guided vehicle that sustains flight through aerodynamic life for most of its flight path and whose primary mission is to place an ordnance or special payload on a target."(56). This definition today includes unmanned air vehicles (UAVs) and remotely piloted helicopters or aircraft (RPVs). Cruise missiles are easier to obtain, maintain, weaponize, and employ than ballistic missiles. Ballistic missiles are not favored as BW delivery vehicles due to the speed and heat generated during re-entry on the warhead or nosecone of the missile. Since many BW agents can be destroyed by the heat and blast effects from a warhead, spraying as an aerosol is the most favored method of dispersal for a BW agent. Cruise missiles have the advantage that a properly sized aerosol dispersal system could be installed within the missile. Once installed, the cruise missile could deliver a BW aerosol over a large swath onto a densely populated area resulting in mass causalities (56). Some cruise missiles have extremely accurate navigation systems, using terrain contour matching (TERCOM) guidance systems, whereas others have guidance systems using the Russian Global Navigation Satellite System (GLONASS), US Global Positioning System (GPS) or the Differential GPS (DGPS) systems. With these systems, the accuracy of targeting by cruise missiles is far superior to ballistic missiles (56).

Kiziah (28) discusses the biocruise threat from the perspective that a biocruise attack could provide "plausible deniability" from a rouge nation. If the attack was done at night, a long range land attack cruise missile (LACM) could be directed to disperse the BW agent while programmed to fly a circuitous route to the target. After dispersal, the missile could be programmed to crash in the ocean or self destruct. Since cruise missiles fly low, (some below radar detection level) as well as have a small Infrared (IR) and radar signature; this makes

detection of cruise missiles difficult. Further, it must be noted that cruise missiles can be launched from sea (even launched covertly from a cargo or tanker ship), from the air, as well as from a submarine. Kiziah also discusses the problem of cruise missile proliferation, especially to rogue states. The major proliferation pathways for rogue nations are: direct purchase of complete LACM from another country; indigenous development of LACMs; with or without outside assistance; and conversion of anti-ship cruise missiles or UAVs to LACMs. The proliferation of cruise missile technology will only enhance the threat of biocruise and a serious BW attack on civilian or military centers in the coming decades (28). Also, as rogue nations may transfer technology and weapons to terrorist groups, it is conceivable that the threat from a terrorist based biocruise will increase or in fact occur.

B. BLACK BIOLOGY

Black Biology is defined as the use of recombinant DNA technology towards the development of Biological Weapons. With the rise of biotechnology and the understanding of molecular biology of pathogens, the applications of recombinant DNA to enhance the virulence of BW agents began (16, 27). One example of black biology was the work done by Sergei Popov, a department chief in the Soviet bioweapons program (16, 27, 44). Popov was able to insert the myelin-producing gene into Legionella. Upon infection of guinea pigs, the pathogen created a delayed neurological degeneration syndrome; the guinea pig immune system eventually destroyed the myelin sheaths on the guinea pig nerves resulting in paralysis. Popov also reported success in developing a strain of plague that was resistant to multiple antibiotics and a strain of anthrax that was resistant to both the anthrax vaccine and multiple antibiotics.

Ainscough describes the revolution in biotechnology and molecular biology as a potential Revolution in Military Affairs (RMAs). RMAs require four essential elements: technological advancement, incorporation of this new technology into military systems, military operational innovation, and organizational adaptation that basically alters the character and conduct of the conflict. With the onset of genetic engineering, it is only a matter of time before black biology creates new BW that become the RMAs of the 21st Century (27). In 1997, a group of academic scientists (the JASONS Group) met to discuss the threat of black biology on BW. This group of scientists defined six broad groups of genetically engineered future threats: Binary BW (two part innocuous system that become lethal once mixed together); Designer genes (genes added to

pathogens to create new combinations of diseases); Gene therapy as a weapons (using the techniques of gene insertion to deliver sickness or death into the cells); Stealth viruses (using a cryptic viral infection to deliver death at a latter time or to a targeted segment of the population); Host-swapping diseases (creating diseases such as a virus that switches species targets and hence would be highly virulent to the new host); and finally designer diseases (diseases created to target a desired set of tissues and create a desired set of symptoms) (27).

Daly (3) replies to the threat of black biology by examining how understanding the genomics of various organisms will help in understanding genetically altered BW. Daly discusses how some extremophiles and their genes for specific traits could be used for genetically enhanced BW. For example, using thermophiles (heat loving organisms) might provide traits to build better heat resistant BW that would withstand explosive dispersal from a missile or withstand the febrile state inside of human hosts. Barophiles (pressure loving organisms) traits could help design BW that withstands the high pressures during the detonation of a BW warhead. Radiation resistant bacteria, such as *Deinococcus radiodurans*, could provide traits to create BW that is resistant to radiation as well as desiccation (3). Daly states that *D. radiodurans* would be a good candidate for the development into a BW agent because of the following qualities: extreme resistance to acute and chronic radiation; extreme resistance to desiccation; high resistance to decontamination via disinfectants; very tolerant to solvents; and highly amenable to genetic engineering. Daly notes that in the future, rather than build a BW organism from scratch, it may be simpler to engineer BW attributes from 1 up to 4 traits into organisms that are naturally environmentally robust.

Finally, Zilinskas (57) discusses some of the targeted traits that black biology could be directed to improve BW agents. These include increased hardiness against desiccation or UV damage; resistance to antibiotics or antiviral drugs; enhanced infectiousness by enhanced binding to target cells; increased pathogenicity by enhancing virulence factors (e.g. local effect enzymes, distant effects toxins, and evasion of host defenses); modification of host specificity (either expanding the host targets of non-human pathogens to humans or reducing the host specificity to select ethnic or racial groups); increased detection avoidance (altering antigens of a pathogen so the immunized patient still becomes infected); and modified senescence (cells self-destruct on cue). Zilinskas describes one very important point at the conclusion of his paper. Zilinskas states that he has not seen much discussion on the problem of pleiotropic effects for genetically

altered BW agents. Pleiotropic effects are the genetic effects of one gene on multiple traits. It can also be described as the unforeseen effects due to the genetic manipulation of the organism. For example, by inserting other genes into an organism, the organism may not act as robustly, but rather become very fragile and unstable in many environments. These pleiotropic effects may result in an undesirable BW agent. Antagonistic pleiotropy refers to the expression of a gene that causes multiple competing effects (some maybe beneficial, whereas others maybe be detrimental). BUT, if the genetically altered BW agent does not undergo "field testing" before use, it could be possible that the pleiotropic effects might result in more damage to the environment or result in an uncontrollable epidemic (57).

9. BIODEFENSE EFFORTS AND RECOMMENDATIONS

A. CHALLENGES

The challenges to the military dealing with BW will be to "think the unthinkable" (54). In the coming years, more advances in detection technology will be directed at early detection ("detect to warn" rather than "detect to treat"), rather than detection after the BW agent is present and personnel are demonstrating symptoms. This will be difficult as the nature of BW is to allow for clandestine dispersal and the only evidence may appear in emergency rooms and doctor's offices (31).

Treatments will need further advancement including research on any new genetically modified BW agents that arise. Alibek and Cerys Rees's work (16, 51) will be critical to create non-specific immune responds that will allow for a blanket immune response to any BW agent. Nonspecific immune responses may also be the critical first line of defense during a BW attack with a genetically altered agent. Some defense the agent would be better than no treatment at all.

Containment of dual use technologies and technology transfer of BW will be difficult. This will eventually require coordinated exchange of information amongst various intelligence and law enforcement agencies across the globe. Although funding to re-direct BW scientists into more productive work (such as what occurred in Russia in the 1990's) has borne some fruit, many other scientists and technicians have been reported hired in other countries, perhaps sharing designs of old Soviet BW technology (44).

Communication needs to be enhanced between various government agencies (Defense, Homeland Security, Agriculture, Centers for Disease Control) as well as local and state agencies and testing labs. Much of the information can be electronically transferred. In the age of the Internet, the Program for Monitoring Emerging Diseases (ProMED), provides communication with sentinel stations across the globe that report unusual disease outbreaks (31). It is conceivable that with the membrane of communication-the Internet-communication between the testing labs, the first responders, the agency directors, the law enforcement, the military, and the intelligence agencies can be woven together into a real time instant meeting sharing data. Planning strategies, issuing evacuations and quarantines, and distribution of vaccine or drug treatments to the population could be rapidly and effectively coordinated. By effective use of information technology, it is possible to reduce the time from the actual BW attack to treatment which would reduce the mortality rates and hinder the success of the BW attack.

Finally, in deterrence, governments (globally, not just the US) must make it very clear the consequences of a BW attack by an aggressor nation, rouge state, or terrorist organization (50). Any nation that uses the deterrence of punishment or escalatory acts, must not only have the capability to issue the deterrence, but the will to issue the action if the BW event occurs (50).

B. DRILLS

One other means to deal with the biodefense challenge is simulated drills of BW attacks. Drills provide administrators and key personnel with concepts and experience in hopes that they will improve their work performance during an actual BW event. TOPOFF (name stems from the drill engaging only "Top Officials" of the US Government) was a $3 million exercise which took place in May 2000 (58). Its purpose was to test the readiness of top government officials to respond to terrorist attacks directed at multiple geographic locations. In three US cities the following events took place: Portsmouth, NH a chemical weapons event; in Washington, DC a radiological event; and in Denver, CO a bioweapons event. TOPOFF was intended to be "player driven" event (i.e. the participants decisions and the subsequent consequences were the primary drivers in the shaping of the exercise). TOPOFF was also a "no notice" drill (i.e. participants were given no formal advanced notice of the nature or timing of the event so their reactions and decisions were as close to reality as possible).

Inglesby (58) describes the results of the TOPOFF drill. The drill revealed problems with leadership and decision-making as well as difficulties of priorities and the distribution of scare resources. TOPOFF also revealed the discord created as contagious epidemics strain health care facilities as well as the need to develop sound principles of disease containment. Flaws in the distribution of drugs to the population were also revealed by this drill. Overall, TOPOFF provided lessons that would help shape future bioterrorism response planning at all levels of government.

Other tools to assist in drill simulations include scenarios designed by BW and public health specialists. The reader of the scenario can analyze what critical component or resource is necessary to control or contain the BW attack. O'Toole (59) uses a bioterrorist attack using smallpox to demonstrate how failures in communication can lead to an initial attack and subsequent failures to contain the outbreak which later blossoms into an epidemic. O'Toole further describes how fear to enact and enforce quarantine-for the hospital and for the city leads to further spread of the disease. In short, the spread of the smallpox, could be averted by training medical personnel in identifying smallpox (even if they have not seen a case in decades), educating the public on the need for quarantines (even in the 21st Century), making local government more responsive to use emergency powers and enforce quarantines, and speed up the distribution of vaccines to contain or prevent further spread of smallpox (59).

C. BIODEFENSE 85%

Finally, Biodefense Now 85% (Biodefense) was a project to attempt to determine if there were any quick-to-implement ideas using available technologies or capabilities to enhance the protection of military forces against BW (54). The premise was that the 100% defense solution was difficult, if not impossible, to obtain. The ultimate goal was to reduce the BW threat to US and allied forces at fixed bases. The goal was to focus on improving protection in a short time frame of two years (by 2006).

The workshop for Biodefense occurred on October 20, 2004 in Washington, DC where forty-one workshop attendees were divided into four groups. The attendees came from various military, academic, and industrial firms with experience, knowledge, or skills dealing with BW. The groups generated 56 ideas directed at providing a substantial amount of additional protection against BW attack. In order to filter down this number of ideas to a more management number

for the Department of Defense (DOD) to act on, the workshop attendees reviewed all of the 56 ideas and ranked their top 15 choices into three categories (Implemented Quickest, Greatest Benefit, and Implemented Quickest and Greatest Benefit). In reviewing the results, the recommendations ranged from vaccinate all personnel, to educational training for select or all personnel, to modifications of the ventilation systems for base facilities.

It is interesting to note that the idea voted Best Overall as well as Greatest Benefit was called C-BW CONOPS. This term Counter-Biological Warfare Concept of Operations (C-BW CONOPS) means that a doctrine developed by the Combatant Commanders and services, should be developed for all military operations in a BW contaminated environment. This doctrine of operations should be comprehensive for all personnel and for all operations and should address issues such as airfield operations, deployment and redeployment of forces, cargo transport, operating in contaminated areas, re-supply, and disposition of BW-contaminated remains and mass causalities. The authors emphasized that BW should not be sequestered into merely medical or disaster planning, but should be an integral part of war plans, operations, and training. The idea voted Implemented Quickest was the Weekly Commander's Stand-up Briefings. These briefings would provide uniform and frequent briefing to base commanders regarding illness trends. At these briefings, overall disease trends should be reported, including occurrences of infectious diseases such as the flu. The briefing may change to more frequently depending on the threat level (54).

Overall, this process brought together key parts of rapid problem solving, decision making with a team of BW experts, and provided information that DOD could rapidly implement for improving Military facilities readiness to handle BW attacks. It must also be noted that BOTH top ideas focused on information and communication within the military structure.

10. CONCLUSIONS

In conclusion, the development of BW proliferation and genetically altered BW agents as well as new technologies such as cruise missiles and the dual use technologies will continue to challenge military readiness in the face of BW attack. These challenges will demand improvements in communication, detection, treatment, and prevention as the military deals with BW threats from the battlefield and from terrorist attacks. Furthermore, since the military will be called to assist civilian needs during a bioterrorist attack, it will require the military to

enhance their communication and detection resources to better serve civilian needs. With the global threats by rogue nations and terrorists as well as groups capable of obtaining BW technology, it is conceivable that the 21st century WILL be the century of BW.

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