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PROLIFERATION PROFILE ASSESSMENT OF EMERGING BIOLOGICAL WEAPONS THREATS

A Research Paper

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Preface

The Clinton Administration considers countering the proliferation of weapons of mass destruction (WMD) a critical national security issue. This paper focuses on one aspect of WMD–the proliferation of biological warfare weapons.

We selected biological warfare for study because it is the class of WMD that presents the greatest challenge to the U.S. We were able to draw on our team's collective experience of WMD intelligence, arms control, operations, communications, and science to develop a model of a biological warfare program. This model will be the basis for the biological warfare portion of a nationally-directed program to determine and track WMD proliferation.

We would like to thank the Institute for National Security Studies for the funding that made this effort possible. We gratefully acknowledge the patience and technical "know-how" of Dr. Scott Ward of AFTAC, along with the greatly needed insight from the arms control community provided by Dr. David Kay. We appreciate the sponsorship of the Defense Nuclear Agency, specifically that of Ms. Alane Andreozzi-Beckman, and the support we received from two of their contractors at DynMeridian. We owe a special thanks to our faculty advisor, Major "Rad" Widman, who put up with our many questions and helped keep us on track.

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Abstract

The White House's *National Security Strategy* states "Weapons of mass destruction . . . pose a major threat to our security and that of our allies and other friendly nations. Thus, a key part of our strategy is to seek to stem the proliferation of such weapons. . . ." Because of the dual-use nature of the technology and materials associated with development of weapons of mass destruction (WMD), they are attainable to virtually any organization or state desiring such a capability. Considered by many as the "poor man's" nuclear weapon, biological weapons offer a low cost alternative relative to other WMD programs.

This project develops a first generation biological warfare (BW) program system model for use in the DOD's counterproliferation workstation, identifies key issues the U.S. military must address to assure its forces are prepared to fight in a BW environment, and develops a concise BW primer for use by any DOD activity requiring such information.

The greatest lesson to be learned from this study is that only through the collective analysis of all the sub-systems of a suspected BW program will conclusive evidence of the program be found. Still, with current counterproliferation capabilities the U.S. may only be able to slow, not stop a motivated proliferant. For this reason, U.S. forces must be prepared to fight in a BW environment.

Chapter 1

Background

But in the Kurfurstendamm and the Eighth Arrondissment, the explosion of anthrax bombs is hardly louder than the popping of a paper bag.

—Aldous Huxley[1]

Introduction

The lightbulbs filled with bacteria and charcoal particles are secretly and methodically dropped into the ventilating grates of the New York City subway system. An aerosol cloud forms and then rapidly dissipates, drawn by the rush of the trains onto the rail beds, walkways, and unsuspecting riders. Passengers exposed in the first few minutes inhale a million bacteria a minute. Eventually more than a million New Yorkers are exposed to the bacteria resulting from this covert, rush hour release targeted against the busiest New York City transit lines.[2]

Fiction? Hardly. The United States Army conducted this covert "attack" in 1966 using a benign bacteria to determine the vulnerability of the subway passengers to a biological attack. Their conclusion from the New York City test and from open air vulnerability tests on 238 other populated areas in the U.S. confirmed their worst fear: large populations are vulnerable to a biological warfare (BW) attack.[3,4]

The Department of Defense (DOD) has long recognized the threat biological weapons pose both on the battlefield and against civilian populations. These weapons can convey power status to a rogue nation or terrorist organization. Further, BW weapons pose a daunting challenge to international counterproliferation efforts due to four primary characteristics: they are cheap, easy to acquire and produce, offer low risk of detection, and are devastatingly potent.[5] Although approximately 130 nations have signed the Biological and Toxin Weapons Convention (BWC) of 1972 renouncing the development and use of biological weapons,[6,7] nine of those countries are suspected of maintaining active BW programs.[8]

Problem Definition

The Clinton Administration considers combating the spread of weapons of mass destruction (WMD)–nuclear, chemical, and biological weapons, and their missile delivery systems—a "critical" national security issue.[9] The White House's 1995 edition of *A National Security Strategy of Engagement and Enlargement* states "Weapons of mass destruction . . . pose a major threat to our security and that of our allies and other friendly nations. Thus, a key part of our strategy is to seek to stem the proliferation of such weapons. . . ."[10] Because the technology and materials associated with the development of WMD are dual-use–meaning they can be used for both civil- and military-related activities–they are attainable to virtually any organization or state desiring such a capability. Considered by many as the "poor man's" nuclear weapon, biological weapons also offer a low cost alternative relative to other WMD programs. Taken together, these factors increase the likelihood that BW will remain a central focus of U.S.

counterproliferation efforts, which include the full range of activities from non-proliferation through force application to post-hostilities clean-up.

To date, U.S. military forces have not faced the devastating consequences of a BW attack on the battlefield. However, Iraq's clandestine development and fielding of vast quantities of biological agents revealed after the Gulf War likely portends the future for the spread of these weapons. The logic for their development and use is compelling. The post cold-war world is dominated by a single military superpower, the U.S., with its capability to project decisive and overwhelming combat force around the world. Potential adversaries, who are unable to match U.S. military power, have a strong incentive to fight outside the conventions of U.S. strategy. BW weapons offer a means for adversaries, either nation-states or terrorists, to wage asymmetrical warfare.[11] Rather than face overwhelming U.S. firepower and precision weaponry, potential enemies can challenge the U.S. by attacking in unexpected ways, dramatically altering the warfighting dynamic. The military theorist Sun Tzu argued the fundamental principle in war was to "attack the enemy's strategy."[12] U.S. warfighting strategy depends on rapidly augmenting small overseas military forces with much larger, more fully equipped, U.S.-based units. Biological weapons, targeted against our strategic mobility airfields and ports, logistics depots, and troop marshaling areas, offer an effective means for potential foes to counter the U.S. prior to battle field engagement and satisfy Sun Tzu's dictum.[13]

The *1995 Report to Congress* by the Deputy Secretary of Defense (DepSECDEF)-chaired Counterproliferation Program Review Committee (CPRC) identified detection and characterization of biological and chemical agents as the theater commanders-in-chief (CINC) number one counterproliferation priority.[14] The CINCs fully recognize the

threats posed by WMD. During their preparation of regional war plans, the CINCs consider ways to prepare against an adversary's potential use of WMD. There is currently not an automated system capable of providing up-to-date detailed information and assessments on biological weapons to the warfighter. This research represents a step toward providing the CINCs with such a capability.

Current Initiatives

In 1993 the Clinton administration issued a directive to focus U.S. Government (USG) efforts on countering the proliferation of WMD. Initially Congress established the Non-Proliferation Program Review Committee (NPRC) for one year under the chairmanship of then DepSECDEF John Deutch to develop a top-level recommendation on how to achieve President Clinton's directive.[15] The NPRC issued the "Deutch Report" to Congress in May 1994 where it provided many recommendations on how the various USG departments could support the "multi-tiered approach" to countering the proliferation of WMD. The approach focuses on "aggressively" pursuing improvements to aid combatant commanders in their efforts to: deter the use of WMD, detect their locations, destroy them before they are used, defend against their missile delivery systems, fight in a WMD environment, and decontaminate subsequent to their use.[16]

Because of the NPRC's success in identifying recommendations to achieve the President's counterproliferation directive, Congress established the CPRC to succeed the NPRC for two more years to track the progress of the earlier recommendations and to make further recommendations and program modifications. Under the purview of the CPRC, the DOD developed four major objectives: support overall USG efforts to

prevent the acquisition of WMD, support USG efforts to "roll back" proliferation where it has occurred, deter the use of WMD and their delivery systems, and adapt military forces and planning to operate against threats posed by WMD.[17]

In line with the CPRC objectives, the Chairman of the JCS (CJCS) designated counterproliferation as one of the nine areas for study under the *Joint Warfighting Capabilities Assessment*,[18] the CJCS's continual process to obtain a systemic view of joint warfighting capabilities and provide guidance for developing requirements recommendations.[19]

Thesis Statement and Approach

This research project develops a first generation BW program system model and proposes that the model will be the basis of a powerful tool for counterproliferation-related analysis. Additionally, this project will provide a concise BW primer for use by the Air Command and Staff College and any other DOD activity requiring such information and it will identify key issues the U.S. military must address to assure its forces are prepared to fight in a BW environment.

The research effort is in support of the DOD's counterproliferation initiative. The model developed in this study is the basis for initial development of the BW portion of the Proliferation Path Assessment and Targeting System (PPATS) counterproliferation workstation–a joint Defense Nuclear Agency/Defense Intelligence Agency program. PPATS will provide a single integrated system to display and model existing and emerging WMD capabilities of proliferating countries and will be available to DOD warfighters, decision makers, and intelligence analysts.

The key functional capabilities PPATS will allow a user are threefold. First, PPATS will identify and track critical research and development, acquisition/production, and deployment steps that constitute a country's proliferation path. Next, it will analyze generic political, economic, and military susceptibilities associated with critical elements of the proliferation path. Finally, PPATS will assess the impact of military actions against specific WMD facilities, including the potential for collateral effects resulting from the release and spread of chemical agents, nuclear material, or biological agents.

PPATS integrates all types of intelligence with information received through other sources, such as voluntary country declarations, to build WMD profiles on countries suspected of proliferation activities.[20] As information from a variety of sources is received, it is parsed, reduced to focused findings, tagged, and filed in a country profile to track that country's progress. As an example, information that a country is acquiring a vaccine plant and is also conducting new military training practices in protective gear might normally not raise suspicion if taken separately. But when correlated with other seemingly innocuous information, a picture of a potential BW weapons program may emerge.

According to the CPRC's most recent report to Congress, PPATS is relevant to countering the proliferation of WMD and will "assist in identifying critical steps in the proliferation process. . . ."[21] To do this, PPATS relies on well-defined process pathway models where each step in the process is a bin that receives information specific to that process. The models for chemical and nuclear weapons programs are already built. The model developed by this research effort will be the foundation on which a comprehensive BW pathway model is built.

This paper draws on sources and interviews from the counterproliferation, intelligence, and scientific communities integrated with concepts from the military war planning and execution processes. It concludes with suggestions for better preparing our military forces for the BW threat.

Scope and Assumptions

This research covers potential steps and paths available to a proliferator, whether a terrorist group or a nation, in the development of selected BW weapons. However, the paper is geared toward BW weapons development by a nation. This limitation was set in order to focus on the more robust BW programs that would be of greater impact to U.S. military forces. The two specific BW agents for study, *anthrax* and *botulinum toxin* were chosen by the developers of the PPATS because they are considered the most commonly studied and produced by proliferating nations.

This research assumes that the proliferation of BW will continue because of ineffective non-proliferation–the subset of counterproliferation aimed at preventing proliferation–capabilities. It further assumes that third world countries will continue to pursue BW programs because of the relatively low cost, minimal requirements of expertise, and ease of concealment.

To help readers through this subject, a glossary of definitions, terms and acronyms is provided in Appendix A.

Notes

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[6] Michael Moodie, "Arms Control Programs and Biological Weapons," in Brad Roberts, ed., *Biological Weapons - Weapons of the Future*?, (Washington D.C.: Center for Strategic and International Studies, 1993), 48.

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Chapter 2

BW Primer

It is better to carry out the bloodiest battle than to quarter the troops in an unhealthy place.

—Napoleon Bonaparte[1]

Introduction

This chapter begins with historical examples of biological weapon use. The second section defines and explains the characteristics of BW agents, establishing what constitutes an effective BW agent, and introducing the two agents whose production paths were studied–*anthrax* and *botulinum toxin*. The final section explains why military planners should be concerned with BW.

History

Microorganisms have played a significant role in the history of warfare. Man's ever-increasing comprehension of the microbe world has greatly impacted the effects and implications of BW throughout the last millennia of armed conflict.

A lack of understanding concerning the nature of the microorganisms which caused diseases and even death did not prevent their use. An Athenian expeditionary army sent to confront the Syracusians in 414 B.C. met its demise due to the work of

microorganisms.[2] Although lacking any comprehension of the microbiological cause of malaria, Syracusian strategist Hermocrates lured the invading Athenians to a fatal encampment in a marshy area recognized as a source location for the disease.

Using similar cause and effect logic, a favorite BW tactic of the time involved the disposal of cadavers in the cisterns or wells of ones enemies.[3] One of the most celebrated employments of BW occurred during the siege of Caffa, in Crimea, by invading Mongols in 1347.[4] To break the stout defense of the Genoese, the Mongols launched the bodies of plague victims over the walls of the besieged city. As the Genoese escaped by ship, they unknowingly carried the bacteria causing both bubonic and pneumonic plagues. The resultant "Black Death" in Europe accounted for approximately 25 million deaths during the period of 1347-1351.[5]

The identification of disease-causing microorganisms intensified mankind's ability to wage war using specified microscopic allies. During WWI authorities discovered ampules in the German embassy in Bucharest, together with instructions, for the spread of the lung disease *glanders* in horses.[6] The Germans successfully infected both Romanian cavalry horses and U.S. livestock destined for the allies with this same lesion-producing bacterial disease.[7]

In response to the chemical and biological excesses of WWI, the Geneva Protocol of 1925 attempted to prohibit both chemical and biological warfare.[8] Under this instrument, signatories retained the right to possess BW agents while promising not to indulge in their use.

Despite reservations on their use, BW development dotted the landscape of WWII on both sides of the conflict. In 1942, the British conducted *anthrax* experiments on

Gruinard Island northwest of Scotland.[9] Researchers found viable ground samples of this spore-forming bacteria 40 years after the original experiments. A world away, during their occupation of Chinese Manchuria, the Japanese conducted BW experiments on over 3000 POWs.[10] Japanese Imperial Unit No. 731 conducted this BW research which included the agents of *anthrax* and *botulinum toxin*. Although neither side employed the agents under wartime conditions, the War Reserve Service initiated the U.S. BW program in 1942 due to a study which highlighted the vulnerability of the U.S. to BW attack.[11]

The isolation and identification of deoxyribonucleic acid (DNA) in 1944 opened the door to the influence of molecular biology on BW.[12] Techniques of this field of science gave BW engineers the ability to enhance the destructive effects of BW agents as well as the ability to produce BW agents resistant to countermeasures.

The U.S. BW program included extensive effects research and sophisticated weaponization and employment methods. Researchers conducted some of their BW experiments on an unknowing U.S. population–as mentioned at the beginning of Chapter 1–using non-harmful, "marker" organisms.[13] Other aspects of the U.S. effort included design, development, and procurement of BW ground- and air-deliverable munitions.

In the early 1960s, the U.S. Army embarked on a well funded BW effort entitled *Chemical and Biological Weapons Employment*. This program came to a dramatic halt when President Richard Nixon renounced the offensive use of BW by the United States in late 1969.[14] The dismantling of all U.S. offensive BW weaponry in the following two years paved the way for the BWC in 1972. The original purpose of the BWC is readily seen in its complete title–"Convention on the Prohibition of the Development, Production

and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction."[15] The BWC entered into force on 26 March 1975 with the U.S.S.R. as an original signatory state.[16,17]

Without a valid verification and compliance regime, this convention has done little to stem the tide of BW proliferation. Less than four years after the convention entered into force, an explosion in Sverdlovsk, U.S.S.R. at a BW weapons plant killed over 100 and infected thousands with *anthrax*.[18] Although the Soviets originally denied the evidence, Russian Federation officials later admitted the continuation of a *Soviet* offensive BW capability despite the 1972 BWC.

Advances in molecular biotechnology and genetic engineering continue to move forward the lethality and destructive capabilities of BW agents. The ability to alter genetic code to dictate the structure and functions of cells has frightening implications concerning BW agents.[19] Despite these progressions in the fields of the biological sciences, the Iraqis were able to stockpile thousands of gallons of *anthrax* and *botulinum toxin* prior to DESERT STORM without highly developed molecular biology or genetic engineering programs.[20] The capacity to deploy such weapons regardless of the state of development in molecular biology should give rise to concern.

BW Agents

BW agents can be broadly classified as living, disease causing microorganisms or the non-living, poisonous toxins they produce. The living microorganisms include bacteria, viruses, and rickettsiae (intracellular parasites) that cause infection resulting in physical impairment or death, usually after a brief incubation period lasting from hours to days.[21]

These organisms are introduced to humans by direct contact, inhalation, or through some intermediary organism such as a mosquito. The organism then reproduces itself causing illness or death. The second class of BW agents are the non-living toxins, or poisonous chemical compounds, that are manufactured by various living organisms. Toxins do not reproduce in their hosts, but rather attack their hosts directly. As a result, toxins cause more rapid effects than microorganisms, causing incapacitation or death within minutes to hours.

Of course, the foremost consideration for a military program is the desired effect of the agent. For example, the Ebola virus' mortality rate exceeds 70 percent while the Venezuelan equine encephalitis (VEE) virus causes only temporary incapacitation with a very low mortality rate.[22] Thus, Ebola is more desirable if high casualty rates are the objective, while VEE is more desirable for short-duration paralysis of the enemy. Similar to conventional munitions, there is a bountiful variety of BW agents from which to choose for a specific application. In advance of the Gulf War, Iraq had produced at least seven different biological agents with effects ranging from diarrhea and swollen sores to blindness and death.[23,24]

Bacillus Anthracis (Anthrax)

Anthrax is a disease caused by the bacterium *Bacillus anthracis*, a single cell organism that primarily causes disease in cattle or sheep. Humans contract the disease by skin contact with infected animals, ingestion of contaminated meat, or by inhaling *anthrax* spores, the rugged dormant form of the bacterium that can survive for 20 or more years in the soil.[25] When inhaled, the spores move to the lymph nodes, reproduce, and

attack body tissues causing uncontrollable hemorrhaging. This pulmonary form of the disease is usually fatal within 4-5 days, even with aggressive antibiotic treatment.[26] The lethal quantity is approximately 8,000 inhaled spores weighing about .08 micrograms (for comparison, a paperclip weighs about 500,000 micrograms).[27]

Anthrax is a suitable military biological agent because it is not contagious–there is no threat of spreading *anthrax* to friendly forces—and antibiotic-resistant strains are relatively easy to develop.[28] Its longevity in the spore form gives it a long shelf life and it is stable under a wide range of environmental conditions.[29] While *anthrax* vaccines do exist, multiple shots are required over a 30 day period to afford any measure of protection. These vaccines are not available in large quantities nor are they required for overseas deployment by military members. As with all vaccines, they cannot guarantee protection against high dosages of agent.

Clostridium Botulinum (Botulinum Toxin)

Botulinum toxin, produced by the *Clostridium botulinum* bacterium is the most poisonous non-living substance known to mankind.[30] Six million times more toxic than rattlesnake venom, the toxin kills by affecting nerve endings causing suffocation in humans when chest muscles become paralyzed.[31] The lethal dose when inhaled or injected is approximately .07 micrograms, causing death within 1 to 3 days in 80% of the victims.[32] Unlike *anthrax* spores which can survive explosive dissemination or aerosol dispersal, *botulinum toxin* rapidly loses toxicity when dispersed, making them more suitable as a point target source.[33]

Global Concerns

During a 1993 speech to the UN General Assembly, President Clinton stated:

> If we do not stem the proliferation of the world's deadliest weapons, no democracy can feel secure. . . . One of our most urgent priorities must be attacking the proliferation of [WMD]. . . . I have made non-proliferation one of our nation's highest priorities.[34]

In today's world where the spread of WMD is rapidly increasing, the potential to fight in a BW environment is a reality that calls for a force capable of identifying the threat, taking the appropriate protective measures, and completing the mission without sustaining massive casualties. If we fail, is the U.S. public prepared for the potentially large number of casualties? In fear of such a scenario, the British leased a fleet of freezer wagons during the Persian Gulf war in the event that the Iraqi's would use chemical or BW weapons. The freezers were to hold dead bodies until an armistice was signed so the public would not see them shipped back during the war.[35]

Of the three types of WMD proliferation, BW presents the most serious problems because of the relative ease of production, the dual-use nature of many of the processes, and the minimal laboratory requirements. These characteristics make a BW program easy to hide and difficult to monitor given present capabilities.

The costs to produce BW weapons makes them attractive as well. A UN panel found that to produce equivalent casualty rates compared with BW agents, nerve agents and nuclear weapons were 600 and 800 times more expensive, respectively.[36] For *anthrax* and *Botulinum toxin*, the cost is about $10-20 thousand per square mile of lethal coverage.[37]

The technology required for production of BW agents is analogous to that required for non-weapons programs such as production of vaccine, beer, and wine. A facility built for a non-weapons purpose, such as a pharmaceutical plant or a brewery, could be converted to a BW facility in as little as a few hours.[38] A recent study by the U.S. Army Medical Research Institute of Infectious Diseases states that ". . . as many as 100 countries have the means of making their own biological weapons without depending on expertise from more advanced countries."[39] This number is large because many countries already have a large-scale biotechnical production capability for food, agriculture, and the medical industry along with the infrastructure to support mass-production of BW agent.[40]

The equipment needed for a BW program is also dual-use. Equipment such as brewery fermenters and dryers for freeze drying coffee could also be seen in a BW production facility. Depending on the size of the program, facilities could range in size from a single-family house to a building the size of the U.S. Capitol.[41]

Because a BW program utilizes dual-use technology and equipment, it is very easy to hide from the rest of the world including on-site verification inspections. During over four years of unprecedented intrusive inspections in Iraq following the Persian Gulf war, the UN Special Commission (UNSCOM) on Iraq found no evidence of an offensive BW program. It was not until the defection of Saddam Hussayn's son-in-law that Iraq disclosed that over 20,000 liters of *anthrax* and *botulinum toxin* were produced at four different facilities, including a foot and mouth disease facility.[42] Iraq also declared that it had placed 150 BW bombs and 50 BW warheads at forward locations during the war.[43] In light of these recent declarations and continued UNSCOM inspections, Iraq is still believed to be able to restart its BW program at any time if it hasn't already.[44]

Another reason verification of a BW program may not be possible is because of the problems associated with on-site inspections being placed under the purview of an international organization (IO). An example of this point is with the International Atomic Energy Agency (IAEA) and its role as the "watchdog" over nuclear facilities declared under the non-proliferation treaty. During the twenty-seventh UNSCOM inspection of Iraq's WMD facilities, one inspector was told by a senior member of the IAEA that the IAEA is "in it for the long haul" and has to deal with the Iraqis after the UN resolutions were fulfilled; therefore they [IAEA] wish to keep their relations cordial and gentlemanly.[45] The IAEA official added that the IAEA did not necessarily want to be viewed by other countries as being too intrusive because this could cause denied access to nuclear facilities in other countries. The bottom line is that when an IO is given global monitoring responsibility over a given technology, political agendas often result in diminished capabilities. David Kay, a former IAEA staff member who headed the most successful WMD inspection in Iraq, provided additional support to this concept. He added that an IO charged with monitoring such an activity will tend to be "soft" if, along with being the regulator of the technology, it is also a promoter of the technology.[46]

As with nuclear weapons technology, much BW technology is available through declassified or publicly available military and scientific literature.[47] Information covering all aspects of a BW program from suitable BW agents to their dissemination systems has been available from many declassified publications and scientific compendiums for over two decades. For instance, a public literature study indicates that there are about 30 BW capable microorganisms and identifies those suitable for military purposes.[48] An example of available information on delivery systems is a declassified U.S. Navy report from the

early 1960's that lists various U.S. chemical and biological weapons, describes how they operate, and shows their schematic design.[49]

Summary

Napoleon's preference for fierce battle over encampment in disease ridden locations reflected an early appreciation by military campaigners of the perils of biological agents on a military force. This chapter began by discussing historical examples of BW use as a precursor to potential future military employment. It then defined key characteristics of biological agents and provided a common terminology to describe them, introducing two agents, *anthrax* and *botulinum toxin*, which offer mortality effects like nuclear weapons but at a fraction of the cost to develop. The chapter concluded with an explanation of why we should be concerned about BW. Having established the lethality and concerns over use of these agents, we now turn to the process of making and weaponizing them for the battlefield.

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[46] David A. Kay, Former Deputy Leader of Iraqi Inspections, telephone interview with author, McLean, VA, 23 January 1996.

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Chapter 3

BW Proliferation Model

For a charm of powerful trouble Like a Hell-broth boil and bubble.

—Witches from *MacBeth*[1]

Introduction

Unlike most military weapon systems which require significant amounts of capital to manufacture or acquire, biological weapon development is primarily information intensive.[2] Publicly available literature provides the information needed to pursue this capability. Modeling the development process and characterizing the steps are straightforward; the more daunting challenge for warfighters is to isolate vulnerable critical components of the BW system that might be affected to inhibit biological weapon system development and use.

This chapter steps through the first generation biological weapon system model developed for PPATS. The discussion of the model components will focus on potential vulnerabilities of each step to exposure and negation. The chapter ends with a discussion of the limitations in identifying and influencing a BW program.

The System

This research project examines the ability to identify proliferators by understanding the process adversaries might use to acquire, manufacture, weaponize, and employ biological weapons. The goal is twofold. First, to identify and characterize the steps associated with the development of BW weapons, from their root sources through weaponization and deployment. Second, to determine if there are signatures that separately or collectively reveal if development is underway. Consistent with PPATS development, this effort evaluated and documented the production of two likely biological agents: *anthrax* and *botulinum toxin*, using a nodal analysis approach.

The research group developed an in-depth system model of a BW weapons program. The model was analyzed to determine the system's critical nodes–those components of a system that would cause a system failure or cascading deterioration within the system if affected peacefully or forcefully through counterproliferation activities.[3] The group then looked at each critical node to determine whether the node was a center of gravity (COG) of the system–a critical node which, if affected, would achieve a counterproliferation objective while being vulnerable to outside influence.[4] A macroscopic version of the resulting model is the nodal diagram depicted in Figure 3-1. A more in-depth BW program model and the one that will be used as the first generation model for PPATS is in Appendix B. The shaded boxes of Figure 3-1 are critical nodes of the system that represent the basic steps required for a BW program to provide the capability to develop at least a terrorist weapon.

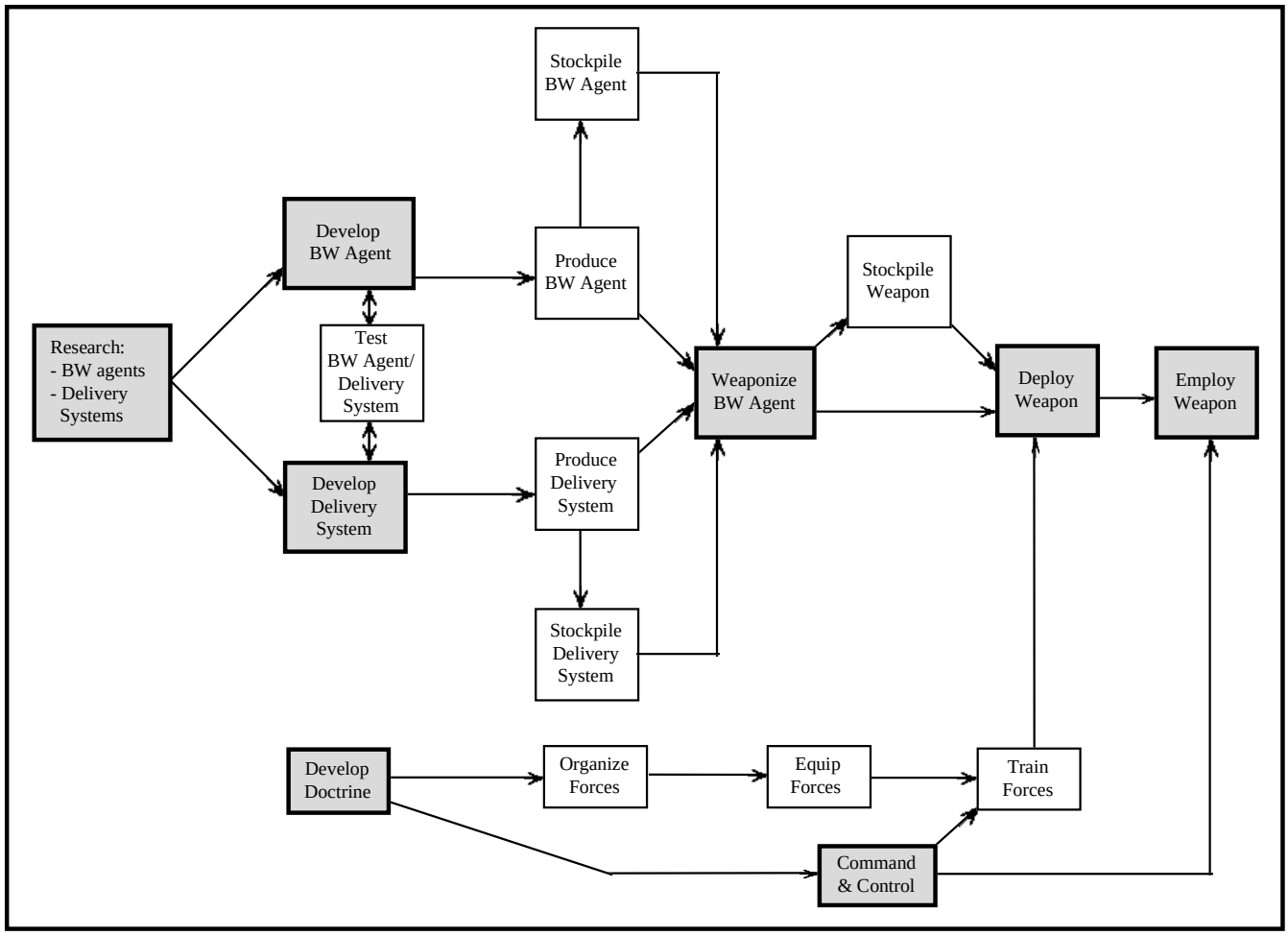

Figure 3-1. BW System Model.

In conjunction with the model, the research group also developed a detailed lexicon of materiel and expertise associated with each phase of the research, development, production, and weaponization of BW agents. The lexicon, included in Appendix C, will be used by the PPATS to determine what information to associate with each node. A lexicon for the remainder of the model is being developed outside the scope of this effort.

Importantly, this study does not address the political and economic decisions and activities which are essential to pursue a BW capability. Such activities could include deliberations whether to proceed with BW development, preparation of budgets and sourcing of funds, organization of facilities, and decisions on whether to ratify and

comply with international BW weapons conventions and submit to inspections.[5] Indeed, the countries most often suspected of BW programs are those which have not signed and ratified the various international BW weapons conventions, or those who have signed but with reservations.[6]

Because the PPATS includes considerations on political intent to proceed with a BW program, the BW nodal model addressed in this paper assumes a decision is already made.

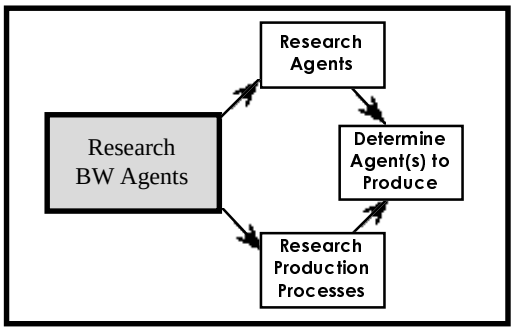

Figure 3-2. Research BW Agents.

Research BW Agents

The public health triumphs over the last century resulted from mankind's exhaustive investigation of diseases on men and animals. The unclassified, publicly available biochemistry, biotechnology, and infectious disease literature painstakingly chronicle the results of this research to prevent and cure these illnesses. This information is readily available and is usable for nefarious purposes by countries or organizations determined to develop a biological weapon capability.

Led by as little as one individual with a masters or doctorate degree in biochemistry, an organization would have enough expertise to research and select a candidate biological agent.[7] Sophisticated databases and networks such as World Data Centre on

Microorganisms, Microbial Strain Data Network, and Microbial Culture Information Service provide researchers information on the specific properties of up to 50,000 microorganisms and the well over 100 locations where they are kept.[8] "Legitimate" researchers–such as those from vaccine or medical laboratories–can order research data and the organisms and have them shipped anywhere in the world.[9] Therefore, the BW agent research phase would likely offer few clues of a clandestine BW program.

This phase concludes with the selection of one or more BW agents and the basic procedures to produce them.

Develop BW Agent

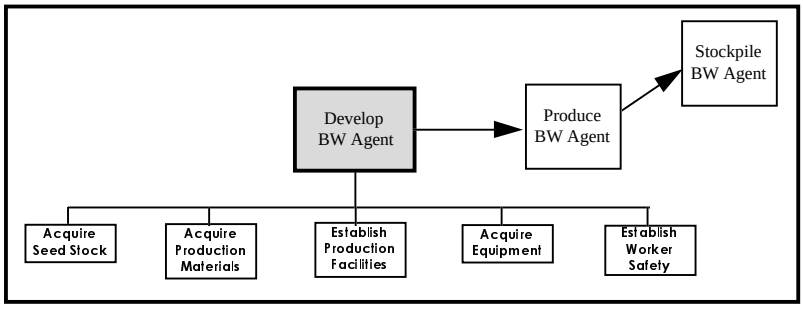

Figure 3-3. Develop, Produce, & Stockpile BW Agent.

This phase includes procuring seed stock for selected agents, procuring materials and equipment, establishing facilities, and developing worker safety. The most likely candidates for biological weapons are the standard agents that have been studied in the past, like *anthrax* and *botulinum toxin*.[10] *Anthrax* can be cultured from infected cattle or spores taken from their hides. *Clostridium botulinum*, the producer of *botulinum toxin*, can be extracted from contaminated food. The small quantities of these or other microorganisms that are needed to begin a program can be ordered from the organizations mentioned in the previous section along with other international microbial production

sources. Acquiring known, effective agents directly doesn't raise suspicion or leave a potential paper trail if the purchaser is linked to a biological research organization.

The basic material required to develop BW agents includes culture media for growth and either chemical or physical sterilization for disinfection. The culture media provide the nutrients for growing bacterial agents and are often waste products from the agricultural sector. Corn steep liquor, a common growth media for both *anthrax* and *botulinum toxin*, is a byproduct of the corn processing industry.[11,12] Byproducts of the cheese making and sugar industries are additional sources of media. These and many other culture media can be easily and legitimately purchased. The optimum culture media for the different agents are again well documented and easily manufactured or purchased.[13] The Iraqi's imported as much as 66,000 pounds of culture medium from Germany, Switzerland and other countries to manufacture their biological agents.[14]

Chemicals used for disinfectant include such common items as bleach, formaldehyde, ammonia, and alcohol. Physical disinfection is possible using steam or high heat.

During WWII, both the U.S. and Japan constructed large scale facilities for the production of bacteria for military use. These facilities included giant batch fermenters, of up to 50,000 liters, full of culture continuously aerated to sustain bacteria growth.[15] Advances in biotechnology equipment have led to computer-controlled, continuous flow batch fermentation which produce the same amount of product using 50 to 100 liter fermenters housed in a much smaller facility.[16] Importantly, the option to produce a terrorist weapon is always available requiring only small 100 liter batches to produce bacteria in the laboratory.

The equipment needed to manufacture bacterial microorganisms includes fermenters, centrifugal separators, filters, dryers, continuous sterilizers, and blenders. This dual-use equipment, similar to the equipment used in making beer, can be acquired commercially without raising suspicion. This equipment is also commonly used to manufacture antibiotics, vaccines, and vitamins.

Although worker safety is paramount in the U.S., developing countries may choose to ignore this, simplifying their program requirements and reducing the overall expense. If safety is a factor, facilities could have various levels of containment and workers would likely be inoculated against the particular agent being produced.

Although the individual acquisition of any of the above equipment or material would not raise suspicion, this phase still offers significantly greater opportunities to determine whether clandestine development may be underway. Associating large purchases of culture media, specialized equipment and material to a single entity may raise suspicion on activities related to a BW program.

Produce BW Agent

The production process is the large scale processing of the agent using methods developed in the previous section. Once the equipment and procedures are in place the process can be managed and monitored by lab technician personnel.[17]

Reports of uncommon diseases, at or near a facility with the requisite processing equipment, resulting from improper waste sterilization, and waste gas emissions may yield evidence of BW agent production. Association of security forces with such a facilty could provide further evidence of a BW program.

Stockpile Agent

BW agent can either be weaponized (discussed below) or stockpiled. Storage facilities for stockpiling are generally environmentally controlled to prolong the shelf-life of the agent. The agent can be stored in common 55 gallon drums in underground bunkers or other such storage facilities.

Research Delivery System

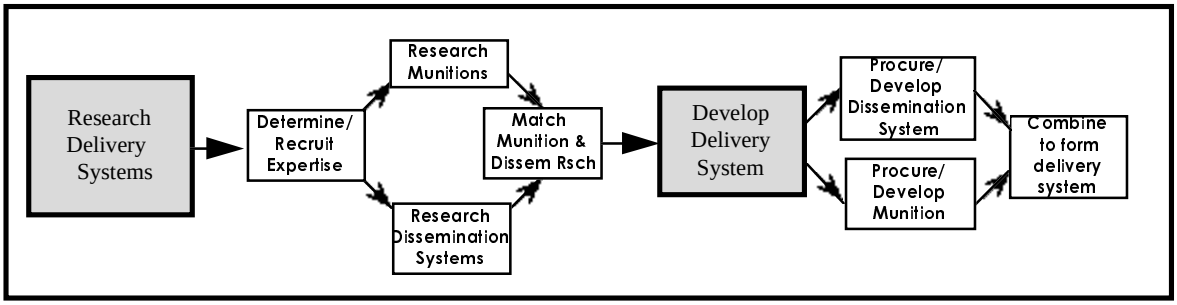

Figure 3-4. Research & Develop Delivery System.

A delivery system consists of the munition, or hardware to carry the BW agent to its target, and a means of dispersing the agent at the target. This step in the overall system includes determining and recruiting the expertise necessary to develop a delivery system, researching the available types of munitions suitable for a BW weapon, researching the dissemination systems to be used with various munitions, and matching selected munitions with suitable dissemination systems.

Delivery systems convert the BW agent into a dispersion of particles, droplets, or vapor and disseminate it to a target.[18] Since ". . . aerosolization is considered the favored route of dispersion, . . ."[19] simply fabricating adaptations to existing weapons systems can be done instead of producing or purchasing BW-unique platforms. As mentioned earlier, much publicly available literature on delivery systems is available, including declassified

USG reports, making this step relatively easy to accomplish without raising outside concern.

Develop Delivery System

Once a proliferator decides on a delivery system, it can either procure the munition and dispersal hardware commercially or develop it using existing or modified designs. The two components are then combined to form the delivery system ready for testing.

Test Delivery System and/or BW Agent

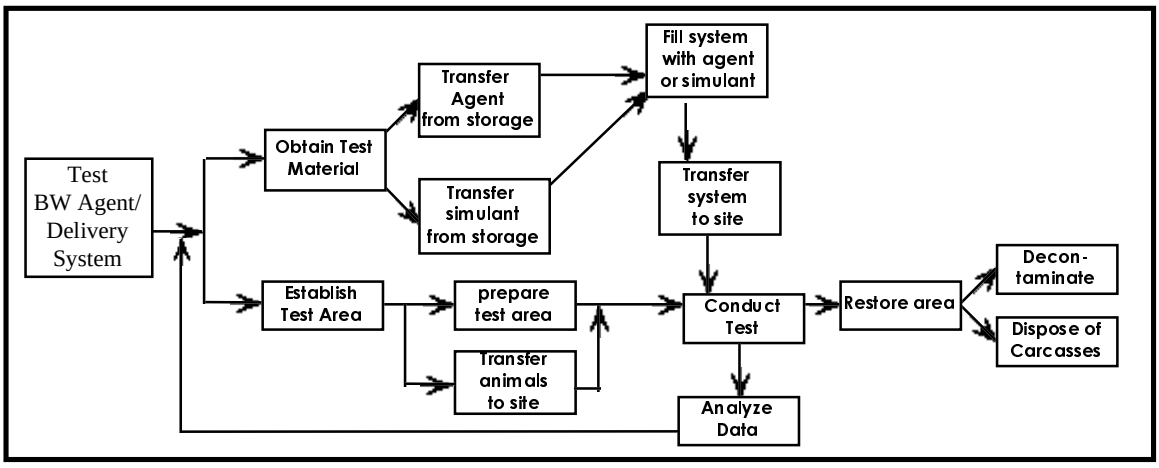

Figure 3-5. Test Delivery System and/or BW Agent

A delivery system can be tested using either real or simulated BW agent. Because the purpose of this step is to test the dispersal capability of the system, a BW agent is not required unless it is also to be tested for its lethality. Tests are usually conducted in either an indoor test chamber or outside over a test grid. If real agent is used, test animals are used to monitor the agents lethal effects–primates are often used but smaller animals are also suitable.[20] This latter type of test also requires decontamination of the test site or explosive chamber and removal of dead, infected carcasses. This phase is a clear

indication of a BW weapon program. For example, a cow pasture in close proximity to a guarded BW capable facility could raise suspicion of a weapons program, especially if animal burial or incineration is also apparent.

Produce Delivery System

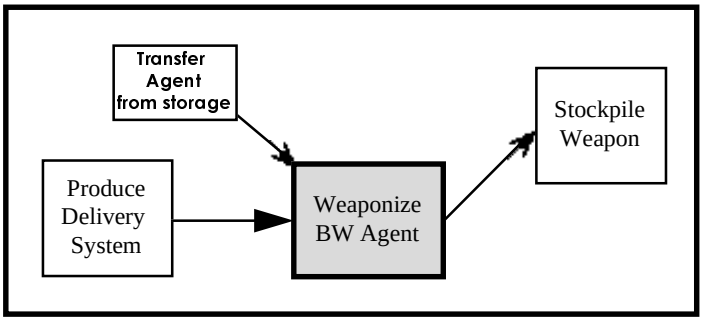

Figure 3-6. Produce Delivery System, Weaponize BW Agent, & Stockpile.

Once a suitable delivery system prototype is developed, the system can be mass produced. The equipment needed to mass produce a delivery system can range from hand-held tools to modify or assemble simple systems to a machine shop with advanced computer numerically controlled machine tools to precisely manufacture munitions or bomb canisters. Completed delivery systems can either be stockpiled for future filling with BW agent, or immediately filled.

Weaponize Agent

Completed delivery systems are filled with BW agent as the final step in the weapon development process. Delivery systems can be filled with liquid agent in a variety of ways. In a less sophisticated program, agent can be manually poured into the system through a funnel. A more sophisticated program may include bulk filling equipment that could automatically fill the delivery systems.[21] When dry agent is used, extra precautions

must be taken because it is much more difficult to contain than liquid agent. Otherwise, the same basic equipment for fill a system with liquid agent can also be used with dry agent.

Stockpile Weapon

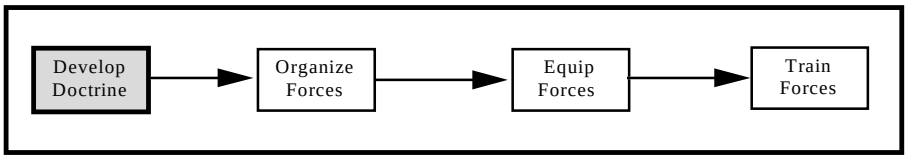

Figure 3-7. Develop Doctrine, Organize, Equip, & Train Forces.

Following weaponization, if the weapons are not immediately deployed they may require strict environmental controls for storage. For instance, *botulinum toxin* is sensitive to heat and light and must be kept in cold storage. However, *anthrax* can be stored at room temperatures because its spore form is less sensitive to temperature.

Develop Doctrine

When groups and nations contemplate the offensive use of BW as a means for attaining their objectives, they must create, adopt, or combine ideas to develop doctrine to guide the organization, equipping, training, and control of BW forces.

The superpower BW programs of the U.S. and U.S.S.R. were on par with each other in terms of scope, size, and sophistication during the height of the Cold War until President Nixon canceled the U.S. program in 1969. Both nations invested heavily in munitions, delivery means, and protective equipment due to the nature of the perceived threat from the other. Their doctrine for BW employment centered around targets of strategic value such as ports, air bases, command facilities, and population centers.[22] BW

employment against crops and animals fell within this doctrine as well. Although the offensive superpower BW programs were dismantled (unverified for Russia), current or future BW proliferators may incorporate certain aspects of either of these nation's doctrine.

States with regional vice global aspirations may have less robust programs in terms of size and sophistication. The quantities and qualities of BW agents required are also much less than the corresponding superpower programs. Strategic and operational targets might mirror the superpower agenda described above and include tactical targets such as unprotected enemy troops.[23] Relative to the superpower efforts, BW doctrine in this category tends toward less efficiency and services a smaller target base.

Requirements for minuscule amounts of high threat agents, such as *anthrax* or *botulinum toxin*, make detection almost impossible. Likely targets include ventilator shafts of key buildings or subway stations, or perhaps a localized area within a population center.[24] Sophisticated special forces operations may be best suited for this type of dispersal.

Organize Forces

BW-specific units are not the norm. Typically units tasked in BW are both chemical and biological in combat orientation. Even so, BW tends to comprise a rather small portion of any combat unit's continuing mission. The exception is the formation of dedicated decontamination units, but these also tend to be dual-hatted in purpose, favoring chemical decontamination. Likewise, elements of the medical corps may be capable of treating a BW-induced epidemic, and such was the case in the former Soviet Union's BW program.[25] Organizations with smaller military arms are less likely to

squander precious manpower in the formation of BW-dedicated units. Thus, offensive BW outfits tend not to grace the command and control charts of any of today's BW proliferators except by asterisk.

Equip Forces

A sophisticated superpower BW program can include a full complement of both offensive and defensive equipment. On the contrary, a terrorist BW program may only consist of off-the-shelf technology for offensive employment with no defensive/safety gear. Likewise, the supporting logistics infrastructure may be stout or lean based on the requirement for offensive and defensive BW-specific equipment.

BW defensive efforts largely center on passive detection systems, protective measures, and medical options.[26] Depending on the sophistication of each BW effort, all or none of the defensive equipment described below may be in evidence. Of note is that current detection systems are not capable of providing large-area coverage and warning. Troops may employ tactical detection equipment such as the Soviet-produced KPO-1 biological agent sampling kit[27] to provide localized agent identification. The next line of defense is protective equipment and facility design relative to the BW threat. Most anti-chemical equipment for the individual combatant will suffice for BW agents provided troops receive ample warning regarding the BW threat. In this instance, the logistical requirements of deploying and sustaining a force with BW protective gear may be significant for a nation such as the U.S. Ventilation fans, water washdown systems, and airtight or overpressurized compartments can provide increased protection for crew quarters or key operational facilities.[28] Medical options for the individual range from doing nothing to preventative vaccinations. Logistics and intelligence are critical in this

aspect because of the extreme specificity of BW vaccines. More sophisticated defensive options include medical corps trained to evacuate and treat BW casualties.[29]

Offensive equipment used to disseminate the BW agent varies from high technology applications to the most rudimentary rigging. High-performance aircraft outfitted with a spraying apparatus could easily dispense a BW cloud upwind of the intended target area.[30] Likewise, a low-flying cruise missile could serve the same purpose. Against point targets, submunitions delivered by aircraft or missile are effective. The proliferation of advanced ballistic missiles obviously has ominous implications regarding the offensive use of BW agents. Older-generation missiles, e.g. SCUDs, may not be a vehicle-of-choice due to the inaccuracy of the system.[31] This inexactness, however, may prove of value for those who wish to use BW as a terror weapon provided the risk to friendly forces and civilians is acceptable. Depending on the area of operations, effective low-technological options can include the mounting of commercial sprayers on platforms such as cropduster aircraft, small patrol boats, or any available ground vehicle. Thus, sophisticated equipment is not a requirement for offensive BW.

Train Forces

Regardless of unit mission, personnel should be trained in the processes which define proper use of their equipment to be combat effective. Offensive BW training usually will consist of simulated BW dissemination due to the inherent risk of employing an actual biological agent to friendly forces or the local population. Offensive training may be combined with BW research by using innocuous or non-pathogenic agents as was the case in the U.S. during the 1950s.[32] Further, observable offensive BW training does not involve necessarily specialized equipment because most weapon systems capable of BW

dissemination are not specific to BW employment. In a similar manner, most BW defensive training also serves the same function as chemical warfare (CW) defensive measures. The familiarization training of personnel relative to their protective gear and the use of decontamination equipment serves both CW and BW needs and is not inevitably indicative of protection from offensive BW employment which may go awry. Likewise, the presence of BW vaccines and the disease-containment training of medical personnel may be purely defensive in purpose. However, one should view with suspicion the absence of any credible regional BW threat combined with the above defensive BW signs. At the terrorist/low technology end of the spectrum, there may be no indications of either offensive or defensive BW training.

Command and Control

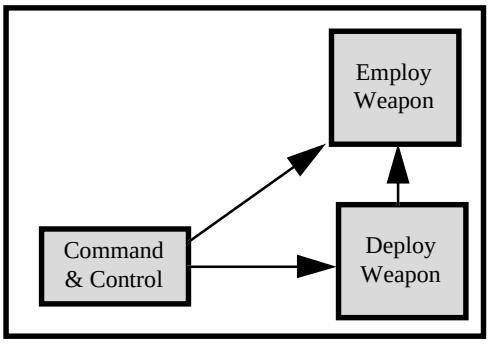

Figure 3-8. Command & Control, Deploy & Employ Weapon.

Command and control schemes regarding offensive BW employment vary as greatly as the size and sophistication of the BW program spectrum. Regardless of the scope of the effort and due to the sensitivity of the issue, it is likely that the highest authority in the organization or nation will retain alerting and execution authority for the actual employment of BW weapons. In a highly developed BW program, this leader may exercise or train with the command and control apparatus prior to the actual use of the

BW agent. On the other hand, the head of a terrorist organization most conceivably will never exercise his or her authority until the time for actual BW employment. Additionally, most decision-makers contemplating the use of BW weapons will require feedback concerning the danger to ones own forces and the prevailing weather conditions, particularly the winds. In any event, one should not assume that the isolation or incapacitation of the authority figure will prevent the employment command from being executed because there may already exist a predetermined set of circumstances which initiates a planned offensive BW episode. Whatever the design and size of the program, command and control of BW forces will be a key component of an organization's overall BW offensive doctrine.

Deploy Weapon

Deployment brings together a fully weaponized BW device with the forces that would use it under guidelines developed in the doctrine phase. However, deployment does not automatically mean a weapon will be used. Consider the previously mentioned case where Iraq had deployed several BW weapons during the Gulf War without ever them.[33] Fear of U.S. reprisal through the potential for use of nuclear weapons likely created this deterrence.[34]

Employ Weapon

Employment of a weapon is the culmination of the BW weapon cycle. However, use of a BW weapon requires a conscious decision in the command and control system. To preclude a belligerent from executing this step, either of the two branches of the system model: weapon development or forces/command and control must be disrupted. The

latter may be the easier of the two to disrupt since it relies more on the human element, to include the understanding of the potential retribution following BW employment. In the case of a terrorist employment, however, the effects of a covertly employed weapon may not be noticed for several days, giving the terrorist organization ample time to distance themselves from the employment site. In such a case, it may be impossible to determine the initiator of such an act.

Limitations in Identifying and Influencing a BW Program

Only through collective analysis of all the sub-systems of a suspected BW program will conclusive evidence of the program be found. For this reason, the model, when expanded and incorporated into PPATS, will provide such utility to the counterproliferation community. The model identifies the system elements while PPATS collates the information relative to the system and places it into a potential proliferant's profile. Still, with current counterproliferation capabilities, the U.S. may only be able to slow, not stop a motivated proliferant because a BW program is not very "vulnerable" to outside influence. This conclusion is based on four findings: BW programs can easily be started, stopped, rebuilt or relocated due to a relatively small infrastructure; the expertise needed for such a program is limited to graduate-level microbiology; the equipment and material needed for a BW program is dual-use and relatively easy to acquire; and on-site verification of BW-related facilities is not likely to provide conclusive evidence of a weapons program for reasons cited in Chapter 2. In light of this, U.S. forces must be prepared to fight in a BW environment.

Notes

[1] William Shakespeare, *MacBeth*, ed. by Sylvan Barnet, (New York: Penguin Books, 1987), 95.

[2] U.S. Congress, OTA, *Technologies Underlying Weapons of Mass Destruction*, (Washington, DC, December 1993), 85.

[3] Maj Paul Moscarelli, "Operational Analysis: An Overview," *Strategic Structures Volume Two*, Air Command and Staff College, (Maxwell AFB AL, AY96): 524.

[4] Ibid, 525.

[5] Raymond A. Zilinskas, "Verification of the Biological Weapons Convention," in Erhard Geissler, ed. , *Biological and Toxin Weapons Today*, (Oxford: Oxford University Press, 1986), 88.

[6] Ibid, 84.

[7] F. Prescott Ward, Ph.D., AFTAC, interview with author, 31 January 1996.

[8] Bernard Atkinson and Ferda Mavituna, *Biochemical Engineering and Biotechnology Handbook*, 2d ed., (New York: MacMillan Publishers Ltd., 1991), 35.

[9] OTA, 84.

[10] Ibid.

[11] Ward.

[12] Atkinson, 832.

[13] Ibid, 35.

[14] Christopher Dickey, "Plagues in the Making," *Newsweek*, v126, n15, (9 Oct 95), 51.

[15] OTA, 88.

[16] Ibid, 89.

[17] Ward.

[18] Stockholm International Peace Research Institute, *The Problem of Chemical and Biological Warfare, Volume II: CB Weapons Today*, (New York: Humanities Press, 1973), 72.

[19] Takafuji, Ernest T., COL, *Biological Weapons and Modern Warfare*, Industrial College of the Armed Forces Executive Research Project S72, National Defense University (1991), 30.

[20] Ward.

[21] Ibid.

[22] Richard O. Spertzel, Robert W. Wannemacher, and Carol D. Linden, *Global Proliferation: Dynamics, Acquisition Strategies, and Responses, Volume IV-Biological Weapons Proliferation*, (Washington, DC: DNA, December 1994), 6.

[23] Ibid, 7.

[24] Ibid.

[25] FM 100-2-2, *The Soviet Army, Specialized Warfare and Rear Area Support*, Headquarters Department of the Army, Washington, D.C. (16 Jul 1984): 13-18.

[26] Takafuji, 43.

[27] FM 100-2-3, *The Soviet Army, Troops, Organization, and Equipment, Headquarters Department of the Army*, Washington, D.C. (16 Jul 1984): 5-137.

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[28] James M. Murphy, MAJ, . . . *From the Sea: Chemical and Biological Concerns*, Naval War College research paper, (17 Jun 1994): 13-14.

[29] FM 100-2-2, 13-17.

[30] Spertzel, 28-29.

[31] Ibid, 30.

[32] Takafuji, 20.

[33] Barbara Starr, "Iraq Reveals a Startling Range of Toxin Agents," *JDW 24*, no. 19, (11 November 1995), 4.

[34] Christopher Dickey, "His Secret Weapon," *Newsweek*, v126, n10, (4 Sep 95), 34.

Chapter 4

BW Counterproliferation

Victory smiles upon those who anticipate the changes in the character of war, not upon those who wait to adapt themselves after the changes occur.

—Giulio Douhet[1]

Introduction

The 20th century has seen dramatic transformations in the way wars are fought and won. In WWII Germany married tank technology, the organizational construct of the Panzer division, and an operational doctrine revolving around armored breakthroughs and aggressive exploitation to create Blitzkrieg, or lightning war.[2] The Germans used this Blitzkrieg in the Battle of France and quickly routed the British and French armies who, despite having comparable technology and force structure, were unable to adapt to this type of maneuver warfare. The Gulf War ushered in the lethal combination of precision guided munitions, which had been in use since the Vietnam War, and a new technological breakthrough–stealth. Flying single aircraft sorties instead of in large aircraft packages, stealthy F-117 aircraft flew only two percent of the attack sorties yet struck nearly forty percent of the strategic targets.[3] The result was a complete decapitation of the formidable Iraqi air defense system without a single F-117 loss. These are examples of how new and old technologies can combine with doctrinal changes to decidedly affect war's outcome.

Will revolutionary new biotechnology techniques make biological agents more effective and discriminate weapons? Will adversaries craft new warfighting doctrine and organizational schemes which promotes their use? The answers to these questions remain unclear and subject to great speculation. When questioned after the Gulf War about lessons learned, the Indian defense minister commented he learned not to engage in a war with the United States unless you have nuclear weapons. As previously mentioned, biological weapons offer a ready, affordable substitute to nuclear weapons with similar mortality effects. Iraq was dissuaded from using its well stocked biological and chemical weapon arsenal by stern warnings from both President Bush and Secretary of State Baker that extreme measures would result.[4] The clear inference was that the U.S. would respond to such an attack with nuclear weapons.

Biological agents are useful as tactical weapons, contrary to the misconception that they are only useful for wholesale slaughter on *Brave New World* battlefields. Although their effects are often unpredictable, due to factors such as weather, agent dissemination, and the uncertain delays in the onset of disease, they can provide a tactical advantage by causing delayed illness or death in forces exposed to the attack. Secondary tactical advantages include psychological effects–such as surprise, shock, and panic–caused by use of such a weapon.

BW agents can also be very effective as strategic weapons, targeted against cities, or against vital economic infrastructure such as ports, airfields, and oil fields.[5] While they represent a redundant capability for a nuclear power, BW agents also represent a powerful equalizing force for a non-nuclear power. For third world countries they can provide a powerful edge over better armed adversaries and protect the legitimacy of a state. Given

the widespread availability of biological weapons and the profound consequences of their use, prudence dictates an aggressive policy of preparedness. This requires a fundamental reappraisal in our thinking about these weapons.

An Immediate Counterproliferation Strategy

According to a recent government report, ". . . U.S. policy should focus on two complementary areas: strengthening existing arms control agreements and improving military defensive posture."[6]

The primary arms control agreement which should be strengthened is the BWC of 1972. The BWC was an attempt to rid the world of an entire class of weaponry by outlawing the development, production, and stockpiling of biological agents and associated delivery systems.[7] However, the short, fifteen-article BWC text left unanswered many questions about compliance, such as what constitutes legal or illegal activities under the convention.[8] As ambitious in scope as it is brief in length, the BWC suffers most from the absence of a viable enforcement mechanism. Except for once-every-five-year reviews, no permanent organization was established to monitor the purely voluntary BWC compliance.[9]

In contrast to its European allies, the U.S. opposes a strict verification regime for biological weapons, arguing the means do not exist to verify compliance with the BWC at a reasonable cost.[10] Instead, the U.S. argues for expanded use of confidence-building measures, such as information exchanges regarding on-going research at laboratories with high bio-safety containment levels, data exchanges on suspicious disease outbreaks, and sharing of research directly related to the BWC.[11] Unfortunately, the four rounds of

confidence-building exercises to date have met with little success–only 36 of the 130 member nations took part and often provided incomplete or ambiguous information.[12] Almost none of the Third World nations participated in the exercises.

The U.S. should embrace both BWC verification and confidence-building measures as part of a broader, more robust BW counterproliferation strategy.[13] While not a guarantor of success, in combination these measures can help identify proliferants and bring the political and military instruments of power to bear against suspected violators. Additionally, U.S. participation in the informal association of nations known as the Australia Group should continue and be broadened. The Australia Group of nations originally developed export controls regarding chemical weapons development, but now has extended these controls to certain biological agents and sensitive BW technologies. One significant weakness, though, is that Australia Group export controls are not formally related to the BWC. Also, because many nations are not part of the Australia Group, countries desiring a BW capability can simply acquire materiel from non-member nations.

The U.S. should actively work to expand the membership of the Australia Group to include all signatories of the BWC and tie BWC compliance monitoring directly to Australia Group reporting. However, strengthening the BWC compliance and reporting measures alone does not address the U.S.'s fundamental concern about BWC verification: that the dual-use nature of BW technology makes it difficult if not impossible to determine if a militarily significant program is underway.[14]

The absence of an effective compliance mechanism in the BWC makes this agreement an undependable ally in the struggle against proliferation.[15] Iraq's success at

hiding their large scale BW program until well after the Gulf War confirms the fundamental shortcomings in this voluntary compliance and disclosure agreement. Until, and unless, the BWC is strengthened, the U.S. military must assume adversaries will be armed with biological weapons and be prepared to respond to them across the spectrum of conflict–from peacekeeping to general war. Specifically, the U.S. must counter the BW threat through the military means of counterforce, active defense, and passive defense.

Counterforce

Counterforce includes interdiction of enemy BW forces, destruction of the sources of BW agent production, and denial of access to BW storage.[16] The military planner must weigh these preemptive options carefully to match the precision of intelligence information with strike choices while taking the necessary precautions to minimize the risk of collateral damage. Certainly, direct attack of the BW agent can be disastrous given the right mix of atmospheric conditions and the close proximity of noncombatants. Active offensive assets include strike aircraft, long-range artillery, conventional and nuclear missiles, and special operations forces.

Active Defense

Active defense includes intercepting and destroying a BW weapon that is en route to its target area.[17] This BW counter centers on air defense assets including aircraft, air defense artillery units, and theater missile defense. These counters would serve to intercept the airborne aircraft or missile systems carrying a BW agent prior to

dissemination of the agent. Since these assets are not unique to the counter-BW mission, other theater operations may compete for them.

Passive Defense

Passive defense measures consists of both medical and non-medical options.[18] The medical side involves both preemptive vaccinations and therapeutic treatment of BW casualties. Intelligence is important to the medical side because of the requirement for accurate information concerning the size and type of agent in an adversary's BW program. These data greatly enhance the ability of the medical corps to be supplied with the appropriate vaccines and trained for the casualties expected from BW employment.

Non-medical passive defense primarily includes detection and identification of BW use, protective equipment for combat use, and decontamination activities.[19] Although BW agent detection equipment is not yet fielded, it is a top USG counterproliferation objective.[20] The real hurdle in BW detection is the real-time identification of the exact agent. Good intelligence preparation can help bound the scope of this problem by assessing the possible candidates of a country in advance of hostilities. The U.S. Army is looking at U.S. requirements for protective equipment and decontamination.

A Vision for the Future

The science of warfare is turning full circle. Historically, the largest source of casualties during wartime has been the inadvertent spread of infectious disease.[21] The intentional use of biological agents on the battlefield threatens to reintroduce these naturally born killers in a more deliberate and malicious capacity. The military cannot

control their development and weaponization but can prepare, plan for, and decisively respond to countries likely pursuing BW programs.

But military preparedness is only one part of the solution. Effective arms control that raises the costs of BW development, heightens the risk of disclosure, and invites prompt and certain international condemnation and punishment must be pursued. This international response should consist of UN resolutions denouncing the violator, imposing stiff trade sanctions, and providing for military action if the violations threaten member nations. As always, the U.S. must be prepared to respond unilaterally if vital national interests are threatened.

Additionally, innovative incentives must be created to assist less-developed nations in enjoying the fruits of the biotechnology revolution in medicine and agricultural improvements, without fear that this expertise and equipment would be used for malicious purposes. For instance, the U.S., through organizations such as the Agency for International Development, could set up cooperative biotechnology partnerships with emerging countries to sponsor vaccine and agricultural research and manufacturing in exchange for unrestricted access to the host nation facilities. The lesser developed countries must be able to realize some benefit from adhering to the voluntary BWC compliance and confidence-building measures if we are to gain their meaningful cooperation.

Lastly, the U.S. must continue to move aggressively to improve its remote sensing technologies to better detect BW agent production or battlefield use. Non-cooperative collections by airborne and spaceborne assets will afford the U.S. and world community a

better appraisal of BWC compliance. PPATS will use these and other inputs from both voluntary disclosures and involuntary non-cooperative detections to populate its database.

The BW system model developed during this effort, when expanded, validated, and incorporated into PPATS, is a significant step in preparing for the worldwide biological threat. It will afford the regional CINCs a vital assessment tool to assimilate disparate pieces of data relevant to the employment of biological weapons. By so doing, PPATS reveals a clearer picture of potential threats. This enhanced use of intelligence data offers opportunities to deter and respond to proliferators using the collective influence and power of the U.S. and other international bodies. For the warfighters, increased familiarity with unique characteristics of biological agent production through this addition to PPATS will result in better selection of targets supporting BW development, deployment, and employment.

The concepts presented in this paper are not new, they merely stress what military strategists have known for years—that vigilance and preparation are key to military success. Nearly two centuries ago Napoleon commented on his many military triumphs:

> If I always appear prepared, it is because before entering an undertaking, I have meditated for long and have foreseen what may occur. It is not genius which reveals to me suddenly and secretly what I should do in circumstances unexpected by others; it is thought and preparation.[22]

A century later the airpower theorist Douhet was among the first to grasp the profound changes to warfare brought on by the invention of the airplane. As the twenty-first century approaches, there are new challenges to U.S. warfighting dominance, such as the increasing threat posed by biological weapons. Future U.S. successes will be measured by the military's ability to prepare for these threats.

Notes

[1] Charles M. Westenhoff, LtCol, *Military Air Power*, (Maxwell AFB AL: AU Press, October 1990), 85.

[2] Thomas A. Keaney and Eliot A. Cohen, *Gulf War Air Power Survey Summary Report* (GWAPS), (Washington, D.C.: 1993), 238-239.

[3] Ibid, 224.

[4] Christopher Dickey, "His Secret Weapon," *Newsweek*, v126, n10, (4 Sep 95), 34.

[5] Brad Roberts, "New Challenges and New Policy Priorities for the 1990s," in Brad Roberts, ed., *Biological Weapons - Weapons of the Future*?, (Washington D.C.: Center for Strategic and International Studies, 1993), 71.

[6] Richard O. Spertzel, Robert W. Wannemacher, and Carol D. Linden, *Global Proliferation: Dynamics, Acquisition Strategies, and Responses, Volume IV - Biological Weapons Proliferation*, Defense Nuclear Agency technical report DNA-TR-93-129-V4 (Dec 1994), viii.

[7] Malcolm Dando, *Biological Warfare in the 21st Century*. (New York: Brassey's Ltd., 1994), 84.

[8] Ibid, 71.

[9] Ibid, 84.

[10] Roberts, 90.

[11] Dando, 79.

[12] Ibid, 79-80.

[13] Roberts, 95.

[14] Ibid, 90.

[15] Ibid, 81.

[16] CPRC, *Report on Activities and Programs for Countering Proliferation*, (Washington DC, May 1995), 4.

[17] Spertzel, 71.

[18] Ibid, 74.

[19] CPRC, 5.

[20] Ibid, 7.

[21] U.S. Congress, OTA, *Technologies Underlying Weapons of Mass Destruction*, (Washington, DC, December 1993), 71.

[22] Westenhoff, 60.

Appendix A

BW System Model

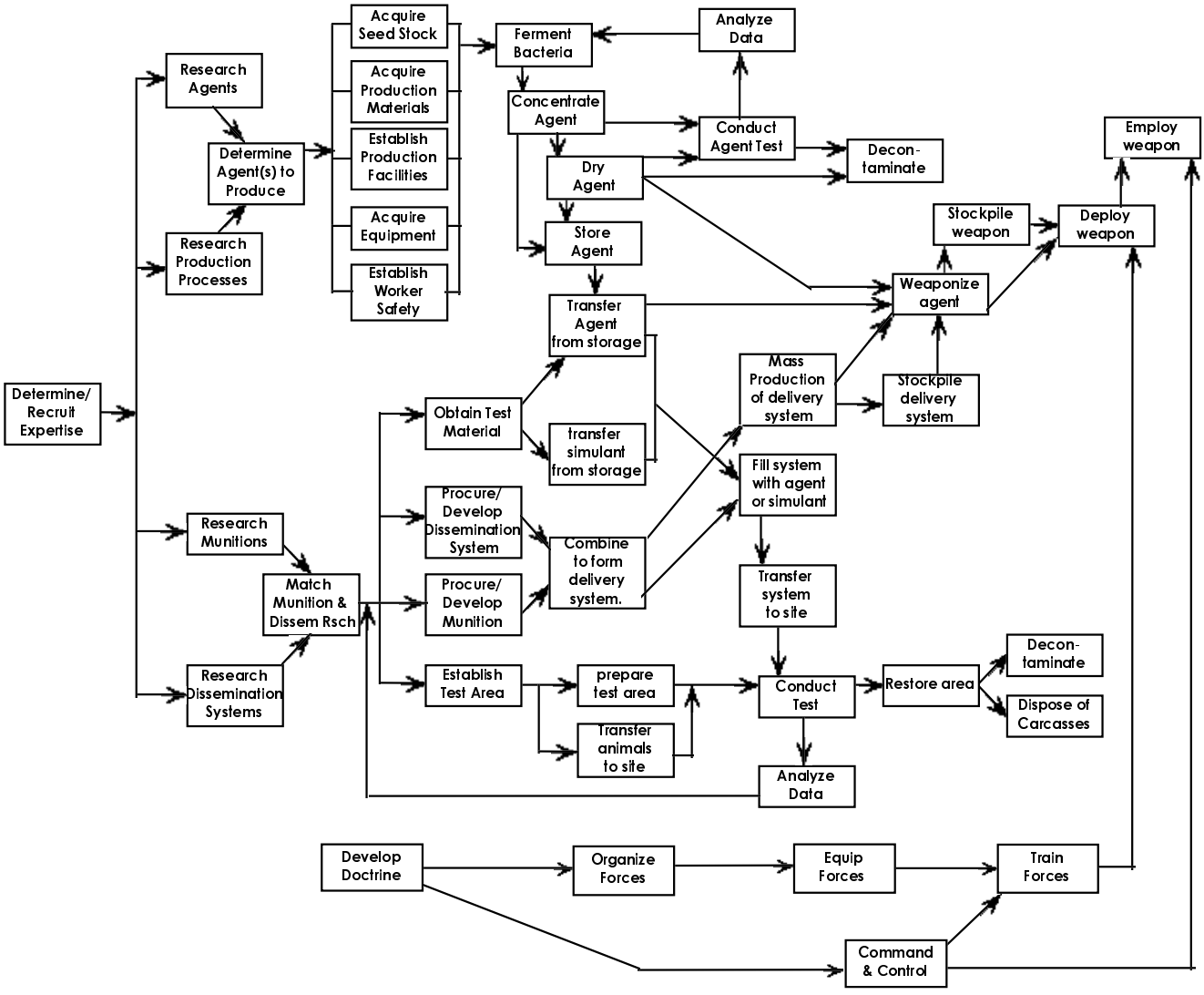

Figure A-1. Micro-level BW System Model.

Appendix B

Lexicon

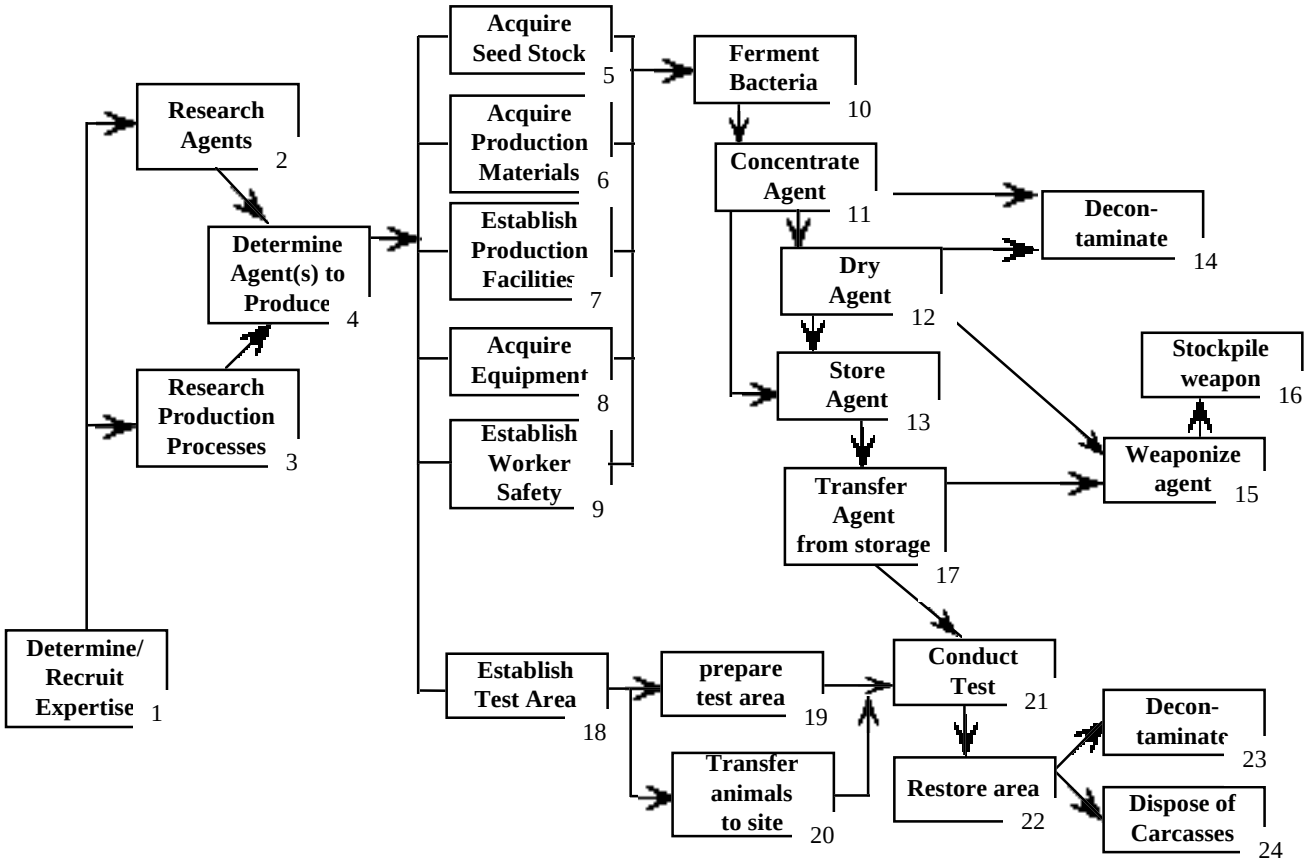

Figure B-1. Lexicon Reference Model.

Figure B-1 depicts the BW agent research, development, production, and weaponization portion of the overall model. The nodes of the figure are numbered to match information provided in the lexicon that follows. The lexicon details the expertise,

material, equipment, and activities required for eac node–only details related to the production of *anthrax* and *botulinum toxin* are included.

Each lexicon entry is followed by a letter and a number describing the category of the entry and its strength as a proliferation indicator. Although this level of detail is likely not needed by anyone besides the PPATS developers, it is included here to show the specific types of materiel needed for a BW program and its obvious dual-use nature. All entries are suitable for both *anthrax* and *botulinum toxin* (*bot*) unless otherwise noted.

Category of entry:	
A	activity
P	personality
M	material
R	related
E	equipment

Strength of indicator:	
1	weak
2	medium
3	strong

1. **EXPERTISE**
   - microbiologist, P, 1
   - technicians, P, 1
   - meteorologist (large scale program), P, 1
   - process engineers, P, 1
   - animal trainers, P, 1
   - security, P, 1

2. **RESEARCH AGENTS**
   - browse Internet, A, 1
   - conduct research at libraries, A, 1
   - request information from universities, A, 1
   - request information from biotechnology laboratories, A, 1

3. **RESEARCH PRODUCTION PROCESSES**
   - conduct research at libraries, A, 1
   - request information from laboratories, A, 1
   - work at civilian pharmaceutical facility, A,1
   - work at civilian vaccine facility, A,1
   - work at civilian biomedical company, A,1

4. DETERMINE AGENTS TO PRODUCE

- review scientific publications, A, 1
- evaluate past BW programs, A, 2
- determine planned use of agent, A, 1
- select agent(s) to produce, A, 1

5. ACQUIRE SEED STOCK

- purchase from research supply house, M, 2
- cultivate from nature, M, 1
- acquire from indigenous civil biotechnology program, M, 2
- acquire from sympathetic government, M, 3
- steal from civil biotechnology program, M, 3

6. ACQUIRE PRODUCTION MATERIALS

- corn steep liquor (culture media), M, 1
- casein hydrolysate (culture media) M, 1
- agar (culture media), M, 1
- barley (culture media), M, 1
- ammonia (culture media), M, 1
- soy bean meal (culture media), M, 1
- caustic soda (*anthrax*), M, 1
- amino acid arginine (*bot*), M 1
- thiamine (in corn steep liquor) (*anthrax*), M ,1
- methionine (in corn steep liquor) (*anthrax*), M, 1
- propylene glycol (anti-foam) (*anthrax*), M, 1
- sulfuric acid, M, 1
- chlorine compounds (decon), M, 1
- yeast extract (*bot*), M, 1
- ammonium sulfate (*bot*), M, 1
- gelatin protein (stabilizer) (*bot*), M, 1
- alcohol, M, 1
- acetone, M, 1
- formaldehyde (decon), M, 1
- glutaraldehyde (decon), M, 1
- sodium hypochlorite (decon *bot*), M, 1
- sodium hydroxide (decon *bot*), M, 1
- polymer coating for encapsulation (*anthrax*), M, 1
- liquid nitrogen, M, 1

7. ESTABLISH PRODUCTION FACILITIES

- bio-safety level 2 microbiology laboratory (developing country), R, 1
- bio-safety level 3/4 microbiology laboratory (advanced industrial country), R,1

- material storage, R, 1
- refrigerated storage/bunker (*bot*), R, 1
- dark storage/bunker, (*anthrax*), R, 1

8. ACQUIRE EQUIPMENT

- 15 L fermentors (lab scale), E, 1
- 50-100L fermentors (pilot scale), E, 1
- 300L fermentors (seed fermentors), E, 1
- 1000-1500L fermentors (pilot scale), E, 1
- 10,000-15,000 L fermentors (full-scale), E, 1
- continuous flow 50-100L fermentors (advanced program), E, 2
- bioreactors, E, 1
- chemostats, E, 1
- Class II/III biological safety cabinets/isolators, E, 2
- high efficiency particulate air (HEPA) filtration equipment, E, 2
- steam sterilizers (*anthrax*), E, 2
- water purifier, E, 1
- incinerators, E, 1
- centrifugal separators/decantors/column separators, E, 1
- spray driers/evaporators (for dry agent), E, 1
- storage tanks >500 gal, E, 1
- decontamination tanks ~80,000 L, E, 1
- 200 L (55 gal) storage drums, E, 1
- protective suits, E, 1
- bulk fillers, E, 1
- heavy truck transports, E, 1
- refrigerator trucks (*bot*), E, 1
- decontamination trucks, E, 1
- assay trailers, E, 1
- containment hoods, E, 1
- animal pens, E, 1

9. ESTABLISH WORKER SAFETY

- develop vaccine, A, 1
- develop serum, A, 1
- conduct inoculations, R, 1
- use protective suits, R, 1

10. FERMENT BACTERIA

- prepare medium/slurry, A, 1
- prepare seed stock, A,1
- mix seed stock and medium (fermentation), A, 1
- induce sporulation (*anthrax*), A, 1

- induce cell lysis (*bot*), A, 1

11. CONCENTRATE AGENT

- decant fermentation mixture (*anthrax*), A, 1
- centrifuge mixture (*anthrax*), A, 1
- precipitate/separate through ion exchange chromotography/ molecular sieving (*bot*), A, 1
- add stabilizers (*bot*), A, 1

12. DRY AGENT

- extract liquid with spray driers/evaporators (*anthrax*), A, 1
- freeze dry (lyophilization) (*bot*), A, 1

13. STORE AGENT

- fill in storage drums, A, 2
- store in refrigerated bunker (*bot*), A, 2
- store in bunker (*anthrax*), A, 2
- protect storage area, A, 1

14. DECONTAMINATE PRODUCTION FACILITY

- chemical decontamination, A, 1
- steam decontamination, A, 1
- use protective suits, A, 1
- hold decontaminated slurry in tank, A, 1
- dispose of decontaminated slurry, A, 1

15. WEAPONIZE AGENT

- transfer delivery system to facility, A, 1
- fill with bulk filling equipment, A, 1
- fill by hand, A, 1
- use protective suits, A, 1

16. STOCKPILE WEAPON

- transfer weapon to storage, A, 1
- store in refrigerated bunker (*bot*), A, 2
- store in bunker (*anthrax*), A, 2
- guard storage area, A, 2

17. TRANSFER AGENT FROM STORAGE

- in refrigerated truck (*bot*), A, 1
- in heavy lift truck, A, 1

18. ESTABLISH TEST AREA

- animal pens, R, 1

- animal incinerators, R, 1
- meteorological towers, R, 1
- refrigerated bunkers, R, 1
- explosive test chambers, R, 2
- aerosol test chamber, R, 2

19. PREPARE TEST AREA
- mark outdoor gridded area, A, 3
- position assay trailers, A, 3

20. TRANSFER ANIMALS TO SITE
- use animal transport (large animals), A, 1
- use standard vehicle (rodents), A, 1

21. CONDUCT TEST
- monitor wind patterns
- disseminate agent with generic dispersal equipment (agent only test), A, 1
- disseminate agent with actual delivery system (weapon test), A, 2
- measure success using assay trailers, A, 1
- report results to leadership, A, 3

22. RESTORE TEST AREA
- remove animal carcasses, A, 2
- remove visible debris, A, 1

23. DECONTAMINATE TEST AREA
- chemically spray outdoor area (*bot*), A, 2
- steam spray outdoor area (*anthrax*), A, 2
- chemically sterilize indoor chamber (*bot*), A, 1
- steam sterilize indoor chamber (*anthrax*), A, 1

24. DISPOSE OF CARCASSES
- incinerate animal remains, A, 1
- bury animal remains, A, 1

Glossary

anthrax. an infectious disease of warm-blooded animals caused by the spore-forming bacterium, *Bacillus anthracis*.[1]

Bacillus anthracis. the spore forming bacterium that causes the infectious *anthrax* disease in animals.[2]

BW. biological warfare; employment of BW agents to produce casualties in personnel or animals and damage to plants or materiel; also includes defense against such employment.[3]

BW agent. microorganisms or their derivatives that can cause disease and be used in weapons to cause incapacitation or death.[4]

BWC. short name: "Biological and Toxin Weapons Convention." long name: "Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction."

botulism. an acute illness resulting from the toxin produced by Clostridium botulinum.[5]

botulinum toxin. a product of the bacteria *Clostridium botulinum*, that is the most poisonous substance known and is the cause of botulism.[6]

Clostridium botulinum. rod-shaped bacteria found in the soil.[7]

COG. center of gravity; critical nodes which, if affected, allow achievement or facilitation of achievement of an objective for the system[8]; the hub of all power and movement, on which everything depends.[9]

counterproliferation. the activities of the DOD across the full range of U.S. efforts to combat proliferation, including diplomacy, arms control, export controls, and intelligence collection and analysis, with particular responsibility for assuring that U.S. forces and interests can be protected should they confront an adversary armed with WMD or missiles.[10]

CPRC. Counterproliferation Program Review Committee; Congressional directed committee to review counterproliferation-related activities, make recommendations, and address shortfall; includes the DepSECDEF, Secretary of Energy, Director of Central Intelligence, and the Chairman of the Join Chiefs of Staff.[11]

critical node. a component of a system that would cause a system failure or cascading deterioration within the system if removed.[12]

DepSECDEF. Deputy Secretary of Defense.

ebola. a fever-producing virus that kills 70 percent of its victims.[13]

IAEA. International Atomic Energy Agency; UN organization responsible for management of nuclear safeguards.

node. a component of a system[14]

non-proliferation. the use of the full range of political, economic, and military tools to prevent proliferation, reverse it diplomatically, or protect our interests against an opponent armed with WMD, should that prove necessary.[15]

NPRC. Non-proliferation Program Review Committee; predecessor to the CPRC; established by Congress in 1993.[16]

PPATS. Proliferation Path Assessment and Targeting System; a joint Defense Nuclear Agency/Defense Intelligence Agency system to assess the activities of a proliferant country, analyze potential counterproliferation options, and access the supporting information.

proliferation. the spread of WMD.[17]

rickettsiae. microorganisms that resemble bacteria in form and structure but differ in that they are intracellular parasites that can only reproduce inside animal cells.[18]

toxin. a poisonous product of animal or plant, or microbial cells which, when inhaled, swallowed, or injected into man or animals, will cause illness or death.[19]

UNSCOM. United Nations Special Commission on Iraq; established as an ad hoc body to monitor compliance with UN resolution 687, the post-Gulf War resolution that requires the declaration of all Iraqi WMD and capabilities, and the destruction and removal of any weapons and capabilities.[20]

USG. U.S. Government

VEE. Venezuelan equine encephalitis; a virus that causes incapacitating disease but rarely death.[21]

virus. submicroscopic infective agent about 100 times smaller than bacteria to which a variety of diseases in animals and plants are traced; reproduces only in living cells.[22]

WMD. weapons of mass destruction; nuclear, chemical, and biological weapons and their missile delivery systems.

Notes

[1] U.S. Congress, OTA, *Technologies Underlying Weapons of Mass Destruction*, (Washington, DC, December 1993), 78.

[2] Ibid.

[3] Joint Pub 1-02, *DOD Dictionary of Military and Associated Terms*, (23 Mar 94), 52.

[4] OTA, 71.

[5] *Software Toolworks Multimedia Encyclopedia (STME),* s.v. "Botulism," version 1.5, (1992).

[6] OTA, 80.

[7] *STME*, s.v., "Clostridium botulinum."

[8] Maj Paul Moscarelli, "Operational Analysis: An Overview," *Strategic Structures Volume Two,* Air Command and Staff College, (Maxwell AFB AL, AY96), 525.

[9] Carl Von Clausewitz, *On War,* ed. and trans. Michael Howard and Peter Paret (Princeton, N.J.: Princeton University Press, 1989), 595.

[10] Institute for National Strategic Studies (INSS), *Strategic Assessment 1995*, (Washington, DC: GPO, 1995), 121.

Notes

[11] CPRC, *Report on Activities and Programs for Countering Proliferation*, (Washington DC, May 1995), ES-1.
[12] Moscarelli, 524.
[13] OTA, 79.
[14] Ibid, 522.
[15] INSS, 121.
[16] CPRC, ES-1
[17] Ibid.
[18] OTA, 79.
[19] OTA, 80.
[20] Jay C. Davis and David A. Kay, "Iraq's Secret Nuclear Weapons Program," *Physics Today*, Vol. 45, No. 7, (July 1992), 21.
[21] OTA, 79.
[22] OTA, 79.

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