STRATEGY RESEARCH PROJECT

BIOLOGICAL AGENT DETECTION SINCE DESERT STORM-- FROM THEORY TO PRACTICE?

BY

LIEUTENANT COLONEL LINDA J. SHOCKLEY
United States Army

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Lieutenant Colonel Linda J. Shockley
United States Army

Dr. Douglas V. Johnson
Project Advisor

U.S. Army War College
Carlisle Barracks, Pennsylvania 17013

ABSTRACT

AUTHOR: Lieutenant Colonel Linda J. Shockley, USA

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Proliferation of WMD, especially biological warfare (BW) weapons, continues apace in today's world, both by nation states and terrorist groups. BW weapons may provide these players a capability which is as potentially devastating as a nuclear weapon at a much lower cost. They will continue to threaten regional stability and may be the primary strategic, as well as terrorist, threat against the United States in the future. An effective and credible biological defense program will minimize the impact of biological weapons in the conduct of U.S. military operations. This goal will be achieved only when our forces have real time detection and identification of BW attack. This paper details the progress made in BW agent detection in the six years since the Gulf War. With two new systems, we have the technology to provide the combatant commander with a credible bio-detection array. What we have failed to do in the near term is to supply the requisite force structure in the Active Component to make the technology work for the commander.

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Introduction

"The one that scares me to death, perhaps even more so than tactical nuclear weapons, and the one we have the least capability against is biological weapons."

-General Colin Powell, 1993

Since the end of the Cold War, the proliferation of weapons of mass destruction (WMD) has assumed epidemic proportions. In the hands of a hostile state, these weapons not only threaten American lives and interests, but also the capability of the United States to project military power to key regions of the world.[1] The Department of Defense (DOD) Bottom-Up Review listed the "dangers posed by nuclear weapons and other WMD, including dangers associated with the proliferation of nuclear, biological, and chemical (NBC) weapons" as the first of the four greatest dangers in a post Cold War security environment.[2] The 1995 National Military Strategy (NMS) also sees the proliferation of WMD as one of four principal dangers on the strategic landscape.[3]

Of these three types of WMD, biological warfare (BW) weapons may be the primary strategic, as well as terrorist, threat against the United States in the future. Chemical and biological weapons have some similarities and are often considered conjointly. However, BW weapons have special characteristics that distinguish them from chemical weapons. Biological agents are inherently different and much more difficult to contain than are chemical agents, primarily because they are either living microorganisms or are produced by living organisms. Detection of biological agents is a complex problem; the lack of

such detection capability during Desert Shield/Storm was probably the Coalition forces' greatest vulnerability.

Since the Gulf War, the DOD has placed renewed emphasis on combating WMD. Some progress has been made in one of our weakest areas--the biological detection and identification arena. This paper will examine the biological warfare threat and the characteristics which make BW unique--and so dangerous--and will consider the progress made since Desert Storm in bio-detection and identification. The threat is real; have we made real advancements in this linchpin of our biological defense program?

Biological Warfare

Within the past ten years, we have begun to lump together nuclear, biological, and chemical weapons under the heading of weapons of mass destruction, which is an old Soviet expression coined during the height of the Cold War. It is dangerous to use one term to refer to these weapons which "do not share:

1) mechanism of injury:
2) preventive measures;
3) basic science requirements;
4) sophistication;
5) or residual effect." [4]

The unique characteristics of biological agents create significant problems in protection and detection which make them such a threat in today's strategic climate.

The world has undergone two "revolutions" in the modern age--the industrial and the information revolution--both of which have dramatically changed warfare. Some authors claim that we are at the beginning of a third one--the biological revolution. The biological revolution may be considered as an extension of the information revolution; it is only possible because scientists have access to the vast stores of genetic data contained in genes, and could potentially remake the biological world though gene manipulation.[5]

At the beginning of the 20th Century, advancements in chemistry allowed the development and subsequent use of chemical weapons in World War I. Then later advances in nuclear physics culminated in the development of nuclear weapons and the use of two fission weapons to end World War II. With genetic engineering reaching great levels of sophistication, it is increasingly likely that BW will be used in future conflicts.[6]

Biological Warfare Agents

Biological warfare agents are living microorganisms and non-living natural toxins which cause illness or death in humans, animals, and plants. Examples of BW agents include bacteria (anthrax, cholera, clostridium, pneumonic plague,), rickettsia, (Q fever, typhus), viruses (Dengue fever, Rift Valley fever, Marburg fever, Ebola), and toxins (botulinum toxin, Ricin, botulinum toxin A, staphylococcus enterotoxin B), to name just a few of the more than a hundred possible agents.[7] Toxins can be produced by a variety of multicellular plants and animals (castor bean plants, mollusks, pufferfish, "poison" frogs) as well as by microorganisms (bacteria, protozoa, fungi).

Genetic engineering and recombinant DNA technology have further expanded this repertory, as was prophesied by Dr. Joshua Lederburg in 1970:

> Recent advances in molecular biology have important implications for human welfare. On the one hand, they help man to a deeper understanding his own evolution and functioning as the most complex of life forms on earth.... On the other hand, molecular biology might be exploited for military purposes and result in a biological weapons race whose aim could well become the most efficient means for removing man from the planet.... My gravest concern is that similar scientific breakthroughs of a rather predictable kind will be made and their potential military significance exploited, so as to result in a transformation of current doctrine about unreliable biological weapons.[8]

Toxins that exist in nature in quantities too minute to be extracted for offensive BW use may now be produced in sufficient amounts through genetic engineering techniques.[9] Recombinant DNA technology could also be used to alter physical properties of microorganisms to make them more resistant to environmental factors, to increase their pathogenicity, or to provide them with greater resistancy to antibiotics.[10] Thus, the biological revolution makes the world an even more dangerous place.

Biological delivery systems can cover larger areas than any other weapon systems; up to thousands of square kilometers. It takes only a small volume of biological agent to dispense very large numbers of infective doses. Reasons for this include the microscopic size of biological agents, their ability to replicate in victims, the potential for transmission

from victim to victim, and the extreme toxicity of certain BW agents. (See Figure 1 below.)

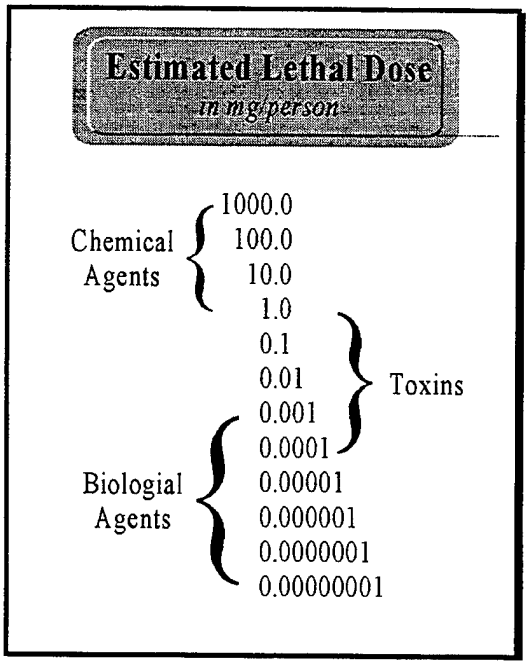

Figure 1. Toxicity of Chemical and Biological Agents[11]

The Threat

Since required reagents are readily accessible and much less expensive than weapons grade plutonium, biological weapons have been called the poor man's nuclear bomb. BW weapons are much more attainable by developing nations than are nuclear or chemical weapons because they require the least technology and capital. While biologicals are cheaper and easier to make than nuclear or chemical weapons, they can have as devastating an effect. Given their ease of production and wide area coverage, along with current U.S. vulnerabilities to them, biological weapons may offer significant advantages to an adversary.

The scientific and technological knowledge needed to develop and produce biological agents in significant quantities is readily available and relatively unsophisticated. In addition to wide availability, the equipment required is dual-use, i.e., suitable for both legitimate commercial activities and illicit weapons production. The agents can be weaponized in everything from missiles and artillery to agricultural crop dusters and back-pack sprayers.[12] Thus, BW are the only WMD which can be effective across the spectrum of conflict. If BW are employed under the cover of an endemic or natural disease occurrence, the attacker even has plausible denial.[13]

Today, as many as 20 countries are suspected of having offensive biological weapons programs. They are listed in Figure 2 below. Note that many of these countries are in the most unstable areas of the world--the Middle East, South West Asia, and Eastern Europe.

Known	Probable	Possible	Doubtful
Iraq	China	Belarus	Algeria
Russia	India	Egypt	Cuba
	Iran	Pakistan	Jordan
	Israel	South Korea	Kazakhstan
	Libya	Taiwan	
	North Korea	Ukraine	
	South Africa		
	Syria		

Figure 2. Nations with Suspected Offensive Biological Programs[14]

States that are hostile to the U.S. may consider BW as an effective counter to our technological superiority in conventional weapons. As stated in Joint Pub 3-0, Doctrine

for Joint Operations, proliferation of WMD has greatly increased the likelihood of their use against friendly forces not only in war but also in operations other than war.[15] Thus, the question is not **whether** BW agents will be used against United States forces or citizens, but rather **when** they will be.

Deterrence

The NMS proposes to counter BW and other WMD by deterring their use and preparing forces to operate effectively in NBC contaminated environments.[16] It may serve as a deterrent for the use of WMD if our forces are prepared for the use of such weapons and able to mitigate and overcome their effects. However, in the post-Cold War era, deterrence will be difficult to achieve regionally. A rogue state with BW capabilities may use them as weapons of choice, rather than of last resort, since one of the reasons such states acquire WMD is the desire to discourage the U.S. from regional intervention.[17] Additionally, in order for deterrence to work by design, a set of conditions must exist:[18]

- The opponent must be rational in a way which conforms to U.S. logic.
- Deterrent options must be believable.
- The threat of U.S. response must be sufficiently lethal and credible so that it will weigh heavily on the negative side in the opponent's cost-benefit calculations.
- Effective communications must exist between the U.S. and the opponent.

If conventional capabilities are not sufficient to deter BW use, the only nonconventional military deterrent available to the U.S. is the use of nuclear weapons. During the Persian Gulf War, hard-line statements made by President Bush, Secretary of State Baker, and Defense Secretary Cheney conveyed that the U.S. would emphatically retaliate if Iraq employed chemical or biological weapons. For example, Cheney warned that if Sadddam Hussein were "foolish enough to use weapons of mass destruction, the U.S. response would be absolutely overwhelming and it would be devastating."[19] The strong inference was that this retaliation would be nuclear. However, writings by these men after the Gulf War stated that they, along with National Security Advisor Scowcroft, agreed that nuclear weapons would **not** be used under any circumstances.[20] This revelation may have severely damaged the credibility of the U.S. threat of nuclear retaliation against future use of WMD by any opponent.

In spite of the threat of nuclear retaliation, especially given the long-standing U.S. pledge not to use nuclear weapons against non-nuclear powers,[21] a regional regime may decide to use BW weapons anyway for a number of reasons:[22]

- It's convinced that its survival is at stake.
- It may speculate that U.S. interests are not important enough for a nuclear response.
- It may gamble that a limited tactical nuclear strike could do no more damage than an all-out conventional attack.

Deterrence, then, requires the continual assessment of the psychology of the rogue nations' leadership, their intentions, and their degree of risk acceptance. Some states with BW may, in fact, be undeterrable.

Counterproliferation

Given the difficulties of deterring WMD, the Defense Counterproliferation Initiative in 1993 gave greater emphasis to WMD counterproliferation requirements. To support counterproliferation, the Department of Defense is concentrating its efforts in four areas:[23]

- passive defense;
- active defense;
- counterforce;
- and measures to counter paramilitary, covert, and terrorist NBC threats.

In the near term, passive defense is the most important strategic concept in countering biological weapons. It includes all those military capabilities that provide protection against biological weapon effects. The major programs are contamination avoidance, including detection, reconnaissance, and warning; force protection, such as masks, clothing, vaccines, and antidotes; and decontamination.[24] By significantly reducing friendly casualties and enabling our forces to continue the fight, strong passive defense, especially when used in conjunction with theater-level programs of intelligence, psychological operations, and deception, will negate the advantages that an aggressor

anticipates through use of BW.

However, today there is a formidable disparity between the magnitude of the biological weapons threat faced by the warfighters and their ability to react to BW use by an adversary. Given the potential strategic and operational impact of BW, a real-time sensing capability is vital to biological warfare defense. With rapid identification and reporting, warning can be given to implement immediate biological countermeasures, both medical and non-medical.

Medical Countermeasures

Many of our current medical countermeasures are only effective against specific organisms or toxins. Consequently, when a biological attack occurs, the most important factor in medical management will be the rapid determination of the specific agent involved. With early detection and identification, appropriate medical intervention can be administered in a timely manner.

This can be critical in saving lives. With some biological agents, medical treatment given before symptoms appear is effective; if given after the victim becomes ill, that same therapy is essentially useless. Two prime examples of this phenomenon are anthrax and pneumonic plague. Both diseases have a latent period of one to four days when antibiotics will save nearly all those who were exposed. Once symptoms appear, however, mortality approaches 100 percent. Timely identification of the causative agent can prevent mass casualties and defeat of our forces.

In lieu of advanced warning, medical products such as vaccines, immunoglobulins and antibiotics can mitigate the effect of biological agents and their potential operational impact. Vaccines cause the body to produce antibodies which can provide a high level of protection for many years. The service chiefs recently endorsed a plan to vaccinate all U.S. forces against anthrax.[25] However, vaccines are highly specific for each agent. Some agents require several inoculations over a period of time before immunity is conferred.[26] In addition, the time needed to develop a safe vaccine product suitable for human use may be 10 to 15 years. While several BW vaccines exist for known threat agents such as botulinum toxin and tularemia, they do not have of full FDA approval and are classified as Investigational New Drugs (IND).[27] Given the rampant speculations on the causes of the "Gulf War Syndrome," use of INDs for future contingencies is highly unlikely.

Immunoglobulins are antibodies which can be harvested from humans or animals. Like vaccines, they provide protection against specific organisms. However, they do not stimulate active production of antibodies by the host and must be administered soon after exposure in order to be effective.[28] The rigorous FDA process necessary for vaccine use approval is also required for immunoglobulins.

The use of antibiotics to treat bacterial or rickettsial BW agents has potential for broad spectrum agent protection. However, antibiotics don't work against viral or toxin agents. With some diseases, timely administration of antibiotics is critical to "curing" the

disease. Additionally, resistance among microbes occurs naturally or can be developed deliberately. Thus, the medical means to mitigate the effects of BW agents are currently incomplete; most depend upon rapid identification of the agent.

Biological Defense Operations

As discussed previously, biological weapons could be used across the spectrum of conflict, in both covert and overt operations. They do, however, have considerable drawbacks as a purely tactical weapon system. For many prospective agents, weaponization is a dilemma--they may not survive the heat from the detonation of an artillery shell or missile. They are weather dependent, both from the dissemination perspective and survivability after release. Which direction will the wind carry that BW cloud? How long after the sun rises will the organism survive? The unpredictability of coverage is perhaps the major disadvantage of biological agents as tactical weapons against front line troops.

Such agents are much better suited for deep operational and strategic missions. They may be used early in a developing conflict for political and psychological purposes in addition to achieving military goals.[29] Particularly lucrative targets are ports of debarkation, airfields, harbors, logistical hubs, and industrial centers, which are especially vulnerable prior to the outbreak of hostilities. Given the perception that the United States is unwilling to accept heavy casualties in combat, biological weapons could be used in an attempt to inflict high casualties and severely erode national will to continue the conflict.

Thus, from an operational and strategic standpoint, the biological detection requirement is to detect large area, aerosol BW attacks rather than small, localized ones. This is a difficult challenge, given the potentially low concentrations of BW agents and the natural backgrounds of innocuous biological organisms and non-living particles within the same size range. For effective detection coverage, both long range and point detection methods are needed. During the Gulf War and for years following, there were no type-classified biological detection systems available to allied military forces. To identify a BW attack, we relied on:

- Intelligence of the enemy's intentions.
- Observation of suspicious munitions or events.
- Epidemiological studies--monitoring illness among military forces.
- Time consuming laboratory analysis, usually at a site far from the theater.

Given the recent disclosures about the failure of the CIA to provide the U.S. military with the information about chemical munitions at Khamisiyah, Iraq,[30] expectation of timely and accurate intelligence is perhaps foolhardy. Also, "suspicious" events often appear so only in hindsight. Both epidemiological studies and laboratory analysis are too time consuming. Reliance on any of these methods will not provide the combatant commander the necessary information about biological attack in time to effectively mitigate the effects or to apprise the National Command Authorities of the confirmed use

of biological weapons.

Biological Warfare Agent Detection

The detection of a BW attack and identification of the agent should set in motion a number of actions which can significantly reduce the effects of the biological attack. Unfortunately, detection of biological agents is a complex problem. Two hours after BW attack, the concentrations of the agents are usually on the order of a few milligrams per cubic meter; the organisms also degrade when exposed to sunlight.[31] And, as previously mentioned, there are hundreds of potential agents. These factors greatly complicate the technical challenges of timely detection and accurate identification.

No real-time BW agent detection systems were deployed during the Persian Gulf War, which highlighted the strategic implications of biological weapons in a regional conflict. This lack of detection capability during Desert Shield/Storm was a great and unacceptable liability. Although Britain, Canada, France, and the United States all deployed air samplers, these only collected and concentrated aerosol particles into a liquid sample suitable for testing with a small antibody-based enzymatic test kit.[32] This ad hoc system took several hours to produce a result for a very limited number of agents and could only determine well after the fact that a biological attack had taken place.

After the Gulf War, in a rapidly accelerated program, the Army used Non-Developmental Items ("off-the-shelf" technology) to produce the M31 Biological Integrated Detection System (BIDS) in record time. It is essentially a compact

microbiology laboratory in a self-contained, environmentally controlled and collectively protected shelter mounted on the back of an M1097 high mobility multipurpose wheeled vehicle (HMMWV). See figure 3 below. Each BIDS section consists of two teams with two soldiers per team. In addition to the BIDS and generator, the section has an additional support HMMWV to transport one team, travel for supplies, and retrograde

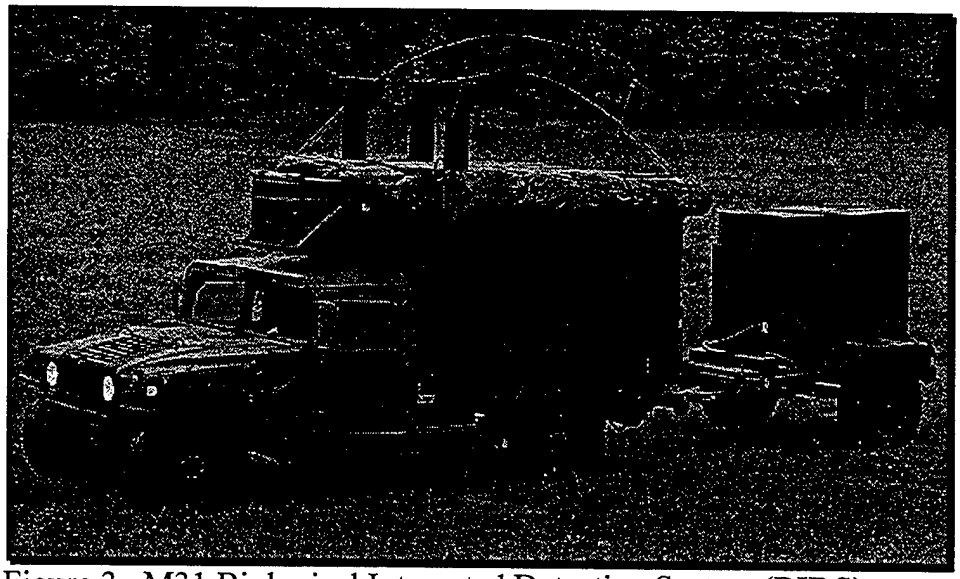

Figure 3. M31 Biological Integrated Detection System (BIDS)

samples. Coming off the drawing boards in 1992, the BIDS underwent Limited User Testing in October 1994, was product improved and tested again in October 1995, and received approved Type Classification - Standard in February 1996.

The instruments in the BIDS will alert to the possible presence of organic material based upon particle size. The operator can then determine if the sample is organic by testing for adenosine triphosphate (ATP), a molecule found in all living things. If that test is positive, then a specific immuno-assay is run to identify the agent. The BIDS can

currently identify anthrax, plague, botulinum toxin A, and staphylococcus enterotoxin B.[33] From alarm to positive ID takes from 30 to 45 minutes.

Given that nearly 50 viruses and bacteria[34] are considered to have potential for BW use, along with nearly 75 toxins,[35] and that each prospective BW agent requires a specific assay to identify, one begins to have an understanding of the complexity of bio-detection. Advances in medical diagnostics and biotechnology are needed to overcome many of these technical obstacles.

By April 1996, an interim bio-detection capability was at last available to U.S. forces when a platoon of seven BIDS and 32 soldiers was certified as mission capable.[36] The first BIDS company, the 310th Chemical Company (minus), with four platoons and 28 systems, was activated in the Reserve Component (RC) on 16 October 1996. Its "fifth platoon" was also activated on that date as an Active Component (AC) detachment (seven systems), the 20th Chemical Detachment. Two more companies, one RC and one AC, will be activated by 2001.

The Biological Detection Company (BDC) will normally be a JTF or corps asset. Doctrinally, the 35 BIDS in the BDC can provide a viable detector network for a three division corps.[37] The distance between each system in an array will be eight to twelve kilometers. In static situations, some systems will be placed upwind of the target to be protected, as well as on the target area itself, to provide warning and detection of an attack.[38]

The BIDS cannot operate on the move; it is a stationary, point sampling system. Both members of a BIDS team will be inside the shelter operating the components. In order to detect BW agents, the BIDS must literally be in the midst of the agent cloud. Maneuver forces are particularly vulnerable to upwind releases of a BW agent; such a release can produce a widely-dispersed cloud with varying agent concentrations. Troops need to be warned of that threat before the cloud reaches them. What is really needed is a stand-off capability to provide real time detection and characterization of BW agents from a substantial distance.[39]

Stand-Off Detection

Over a five-month period in 1993, the first prototype Long Range Biological Stand-off Detection System was built with commercial, non-eyesafe lasers and a Sun computer workstation.[40] Flown in an UH-60 (Black Hawk) helicopter at Dugway Proving Ground, it was able to detect airborne aerosols up to 53 kilometers away. Subsequently, the Army initiated an operational requirement for a helicopter-carried BW detection capability--the Counterproliferation Prototype LIDAR (**LI**ght **D**etection **A**nd **R**anging) program--in 1995.[41] In final development now is the XM94 Biological Stand-off Detection System.

This is an elastic backscatter scanning LIDAR system capable of detecting, mapping, and tracking aerosol clouds which may contain BW agents, to include line-source clouds, at ranges to 50 kilometers.[42] The LIDAR scans vertically as the helicopter flies parallel to suspected threat sectors. It uses laser light to scan distant objects; when the light beam

strikes airborne particles or gases, some of the light is reflected back towards the source. That backscattered light is collected by an optical telescope and focused onto a detector.

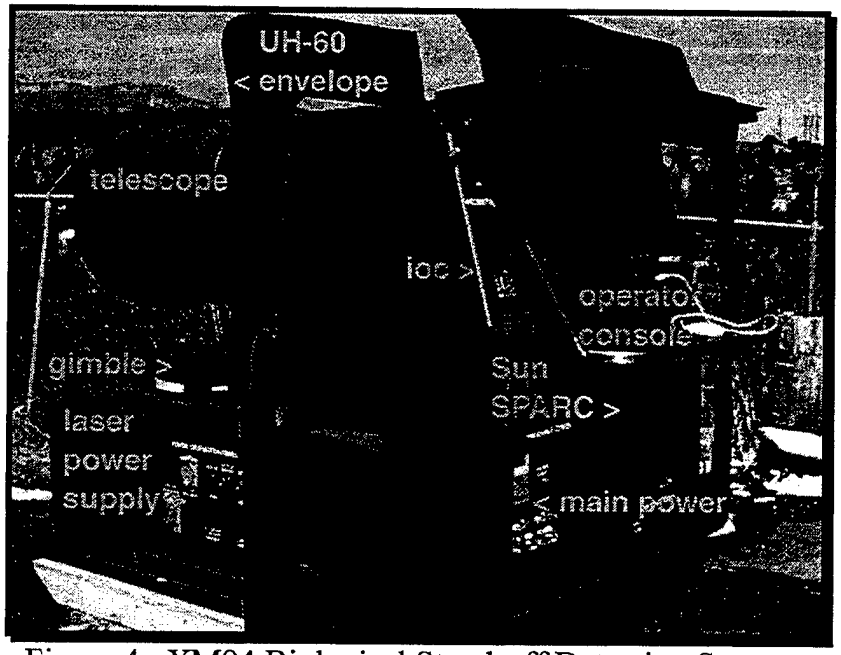

Figure 4. XM94 Biological Stand-off Detection System

The XM94 data system processes the signals generated by the detector and displays them as two dimensional images on a computer monitor. From these images, the operator can determine locations, altitude, distribution, dispersal, and movement of the aerosol cloud. The prototype XM94 System is shown in Figure 4 below.

Unfortunately, the XM94 uses a laser which is not eye-safe. The eye hazard distance is 2.5 kilometers for the unprotected eye and 12 kilometers for soldiers using binoculars or aiming devises. Fielding of the first systems is scheduled for late June 1997 to the 310th Chemical Company.

Discussion

Proliferation of WMD, especially biological weapons, continues apace in today's world, both by nation states and terrorist groups. Biological weapons may provide these players a capability which is as potentially devastating as a nuclear weapon at a much lower cost. They will continue to threaten regional stability and must be taken seriously by the combatant commanders and strategists at all levels. An effective and credible biological defense program will minimize the impact of biological weapons in the conduct of U.S. military operations.

This goal will be achieved only when our forces have real time detection and identification of BW attack, effective immediate biological countermeasures (both medical and non-medical), and rapid dissemination of biological warning information to further mitigate the effects of BW agents. The key components in this paradigm, the elements which trigger all other actions, are detection and identification.

During Desert Storm, coalition forces had only the most rudimentary capability in this arena. We were indeed fortunate that biological weapons were not used, as far as we can tell, against us. After the war, in concert with the National Security Strategy and the NMS, the Chairman, Joint Chiefs of Staff, designated counterproliferation of WMD as one of the nine central Joint Warfighting Capabilities.[43] The Commanders in Chief (CINCs) of the combatant commands in turn designated improved equipment for detecting and characterizing BW threats, especially at long range, as their number one

priority for enhancing counterproliferation capabilities.[44]

As this paper has detailed, some progress has been made in the area of BW agent detection in the six years since the Gulf War. A point detector has been fielded; the BIDS can provide real time identification of a select few BW agents. A stand-off detection capability for aerosol clouds will be fielded in the summer of 1997. The acquisition process for both the BIDS and the XM94 was significantly accelerated. The future is bright; as technologies further mature, newer systems will be able to detect, identify, and characterize an increasing number of biological agents, more reliably, and from greater distances and then integrate the results into warning and reporting networks.

Conclusions

The credibility of the combatant commander's bio-detection capability is questionable even though two new pieces of equipment have been fielded. All of DOD's BW detection assets are contained in one AC platoon-sized detachment and one RC company(-). The AC BIDS detachment is fully manned, well-trained, and ready for the call. The RC company is understrength, particularly in BIDS-trained soldiers, and struggling to become mission capable. Given the location of the unit (rural Alabama), the time it takes to recruit a soldier in the RC and have him/her complete both Chemical Military Occupational Specialty (MOS) and BIDS specialized training, the company may not be deployable until well into 1998 or even 1999.

Newspaper articles about the activation of the 310th Chemical Company have

painted a rosy picture of U.S. biological agent detection capabilities. However, should a Major Regional Contingency (MRC) erupt before 1999, in a part of the world where biological WMD are a threat, our forces would be at significant risk. Only some high priority targets could be protected, in an area about the size of a division sector. Our forces are still at risk for operational difficulties and high casualty rates under BW attack.

For the first time in the 20th century, we have the technology to provide the combatant commander with a credible bio-detection array. What we have failed to do in the near term is to supply the requisite force structure in the AC to make the technology work for the commander. Given the increasing threat of biological WMD, the force structure decision which placed four fifths of the U.S. point detection capability--and all the long-range stand-off assets--in the Reserves for the near term must be overturned. Bring the 310th Chemical Company as well as the second proposed RC Biological Detection Company into the AC.

The world is still a very dangerous place. We face threats today that range from regional instability in the Balkans, the Middle East, and Africa, to the continued proliferation of weapons of mass destruction and the means to deliver them. The potential for use of biological weapons is a terrifying reality. Real-time detection and accurate identification are paramount for mitigating the effects of such weapons when deterrence fails. America's sons and daughters in service to their nation deserve the best that current technology can provide.

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[36]This discussion on BIDS is based upon the author's experience with the system while commanding the 84th Chemical Battalion from July 1994 to July 1996. FORSCOM tasked the unit to provide the platoon to test BIDS and then serve as the interim bio detection capability until the activation of new force structure.

[37] Techniques, Tactics, and Procedures, Biological Defense Operations (Draft), 4-3.

[38]Ibid, 4-4.

[39] Robert G. Joseph and John F. Reichart, Deterrence and Defense in a Nuclear, Biological and Chemical Environment, (Washington: National Defense University Press, 1996), 19.

[40] Scott, 44.

[41] Ibid.

[42] "Biological Standoff Detection System (XM94 LIDAR) System Brief," <http://sst.lanl.gov/groups/nis-3/DataAq/project /xm94/brief.html>, 22 March 1997.

[43] Proliferation: Threat and Response, 49.

[44] Ibid.

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