Combating WMD
JOURNAL
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Issue 7 Spring/Summer 2011

Exercise "Poets Corner" a Multinational Effort to Prevent CBRNE Terrorism

Service-Level CWMD Framework

U.S. - Russian Partnership and the Plutonium Production Reactor Agreement

The Spore Casing as Defense for the "Anthrax" Biological Agent

Decon Emitting Neutralizer of Improvised Explosive Devices (DENIED)

Department of Army's Role in Response to a Domestic Bioterror Attack!

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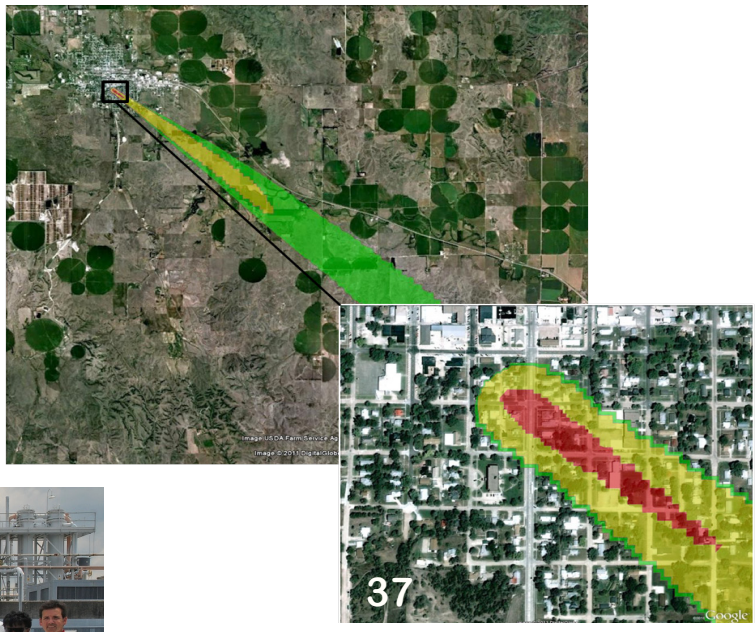

Front Cover: Royal Logistic Corps (UK) EOD Tech positions his x-ray on a RDD in the trunk of a car during CAPEX 2011 Morton-on-Marsh, UK. EOD would later render safe the RDD with a disruptor in order to allow a police forensic team to collect evidence. Photo courtesy of LTC Michael Quinn

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Putting R and N Back in CBRN

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Chemical, Biological, Radiological and Nuclear (CBRN) are weapons, effects and conditions that the Army must be prepared to deal with on the battlefield or within our own borders. Combating Weapons of Mass Destruction (CWMD) is a mission, broken down into eight military mission areas that cross cut the six warfighting functions by which we prevent, protect, respond and recover from CBRN weapons and their effects.

Each of the CBRN weapons and their effects have unique challenges and operational response requirements. The Army has invested a great deal of effort and resources in passive defense, consequence management (CM) and foreign consequence management. However, for nuclear effects and particularly the prevention of nuclear smuggling, the Army's doctrine and equipment, except for a few specialized and elite units, have not progressed much from the Cold War era.

The US and international partners have taken action to address the nuclear threat. Cooperative Threat Reduction efforts have done excellent work in securing nuclear weapons and material from the former Soviet Union. Departments of State, Energy and Defense efforts have identified and secured special nuclear material and radiological sources world-wide and increased national and international capabilities to detect illicit movement of nuclear weapons and the special nuclear material (SNM) that is key to their development. Multilateral initiatives, like the Global Initiative to Combat Nuclear Terrorism, have raised international awareness of the threat. Safeguards under the Nuclear Nonproliferation Treaty allow peaceful use of nuclear technology, while attempting to ensure weapons programs are detected and avoided. Arms control treaties have limited the number of weapons in Russia and the U.S.

CWMD Military Mission Areas

- Security Cooperation and Partner Activies
- Threat Reduction Cooperation
- WMD Interdiction
- Offensive Operations
- WMD Elimation
- Active Defense
- WMD Consequence Management

ARMY Warfighting Functions

- Mission Command
- Movement and maneuver
- Intelligence
- Fires
- Sustainment
- Protection

Despite all these positive steps, the threat from nuclear proliferation and potential terrorist acquisition of nuclear capabilities is expected to continue. Thousands of nuclear weapons still exist, special nuclear materials remain outside of safeguards and vulnerable to theft or diversion, and detection and interdiction of SNM remains a technical and operational challenge. Recognizing this, our national and military strategic guidance documents have articulated the need to increase our focus and capabilities in the areas of preventing nuclear proliferation and terrorism and responding to their use. The Army's Operating Concept for 2016-2028 went as far as specifying that the threat from a terrorist device employed in the U.S. is the "most dangerous alternative."

In the past the Army recognized the requirements and challenges of a nuclear armed adversary. During the Cold War we prepared to continue operations and win when confronted with thousands of tactical nuclear weapons. The basic tenants found in FM 100-30, Nuclear Operations, still apply and are being updated by the Combined Arms Center to better reflect and apply to full spectrum operations. The Army continues to harden essential combat power platforms against nuclear weapons effects. The Army's nuclear survivability program was the model upon which DoD patterned a recent directive for a department-wide survivability program. Vigilance into the future is essential to ensure that when faced with a nuclear threat, our Soldiers and their equipment survive so they can continue the fight. As equipment becomes more and more sophisticated and autonomous, our survivability schema must adapt. We cannot become overly vulnerable to electromagnetic pulse that could potentially affect electronics over thousands of square kilometers.

The Army was also prepared for radiation on the battlefield. We manned, trained, and equipped our organizations to predict, detect and avoid fallout, and decontaminate personnel and equipment. The current multi-service Tactic techniques and procedures (TTPs) found in the FM 3-11 series provides our foundation to conduct CBRN defense and sense, shape, shield and sustain in a contaminated operating environment. The radiation detection equipment fielded to our forces is still adequate for this mission, but, as will be discussed later, is not capable for a wider set of prevention requirements. The recent experience from the unfortunate reactor accidents in Japan has reinforced the Army's need to understand and implement RN defense, not only for the forces conducting operations, but for our civilian personnel at fixed installations. Lessons are still being captured across the Army, DoD, and interagency, but the basic principles laid out for conducting operations in a radiological contaminated environment, whether from a nuclear detonation or a reactor accident, the "fallout" and procedures are basically the same. Unfortunately, on a macro level we neglected our doctrine and TTPs. The Army must institutionalize the forthcoming lessons and refresh the leader awareness and soldier skills associated with these basic tasks.

The Army is best postured for responding to a CBRN employment—actions to the "right-of-boom." National level emphasis is now being placed on prevention measures—those actions to the "left-of-boom." Prevention measures have been for the most part conducted by a limited number of exclusive units and teams. However, the organization of our forces to discover and prevent radiological and nuclear development and employment cannot rely exclusively on a few expert teams. It requires general purpose CBRN forces to have a basic understanding of nuclear weapons program signatures and a set of tools capable of detecting low levels of radiation and identifying the source of that radiation and knowing when to call for additional experts like that resident on an NDT to confirm and further exploit what was found. Further, positive efforts have been taken by DoD to enable the maritime and air interdiction of nuclear weapons and material. However, land interdiction is only now being addressed. As global response plans for dealing with "loose nucs" and preventing WMD terrorism in the homeland mature, the Army needs to develop RN land interdiction strategies and capabilities to support the land component commanders in their emerging counter nuclear missions. Land, air and sea components under command and control of GCCs will have the mainstay of efforts to cover transit routes in an ambiguous environment and assist in developing the situation. For Land Components this is basically application of cordon and search and wide area security doctrine and TTPs with the object of finding nuclear material. Unfortunately, the radiation detectors we have in the force that are so good for nuclear fallout, are not adequate for the interdiction mission. Appropriately, the Maneuver Support Center of Excellence is conducting an experiment to determine the capability and capacity required of the CBRN forces to fulfill this mission.

The Army's challenge is to sustain our efforts in passive defense and CM, maintain momentum for those initiates to exploit and eliminate nuclear programs, and finally define and develop a capacity to support land interdiction of nuclear weapons and material. Putting RN back into CBRN will require added emphasis on training and will require some upgrades to existing equipment. While I applaud the past and ongoing efforts in this area, I also caution that only through vigilance, renewed training on RN, and an institutional adoption of prevention as a priority will the Army meet its responsibilities to the nation in combating nuclear and radiological weapons.

U.S. ARMY NUCLEAR AND CWMD AGENCY
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Service-Level CWMD Framework

Mr. Steven Rollins
Kalman and Company

The Combating Weapons of Mass Destruction (CWMD) Joint Integrated Concept (CWMD JIC) evolves from the National Military Strategy to Combat Weapons of Mass Destruction (NMS CWMD) by defining the objective not as defeating a single device but as defeating a rogue actor or nation utilizing a combination of skill sets (technology, financing, security, etc) to develop, transfer or employ a Chemical, Biological, Radiological and Nuclear (CBRN) weapon. While the Services currently support CWMD-related operations and requirements development, there has been no formal concept or direction to them to define, at the tactical level, the extent and capacity to which these tasks are to be done. This paper merges the objectives and key elements of current Joint CWMD doctrine with the military mission areas and proposes a tactical-level template for designing service-specific plans and concepts for supporting CWMD efforts.

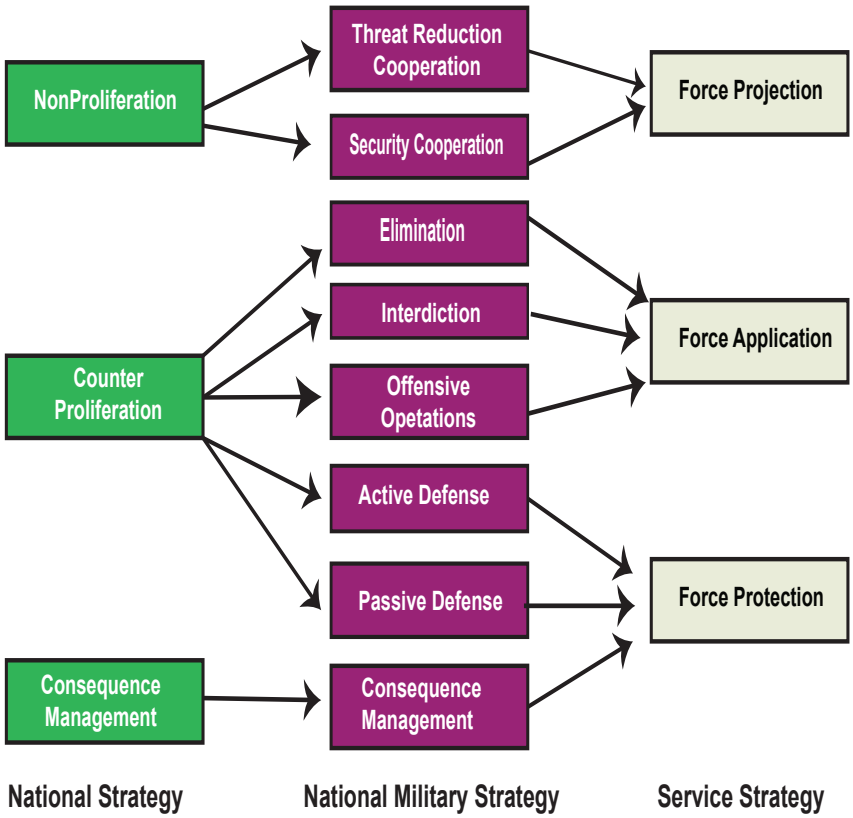

Figure 1. Relationship of CWMD concepts from National Strategy to Combat WMD to National Military Strategy to Combat WMD to Service Framework to Combat WMD.

While much of the focus of CWMD operations is on weapon effects (i.e. contamination hazards), the requirement for the Services to interact with and enable joint, coalition and interagency actions to prevent WMD development, transfer and employment goes far beyond the CBRN Defense community. It is, in essence, a headquarters staff function; similar to addressing counternarcotics and the Global War on Terrorism (GWOT). The additional considerations associated with preventing or mitigating contamination while conducting CWMD operations create challenges and considerations peculiar to this mission set.

Obviously, there is more to the Department of Defense's (DoD) ability to execute CWMD operations than the contributions of the Services. Combatant Commands, Support Agencies (like the Defense Threat Reduction Agency) and other organizations and offices within the Department of Defense all contribute to the overall effort. This proposed concept, however, focuses on the Service contribution and provides a methodology to aid in the overall organize, train and equip direction that is still in line with DOD Directive 2060.02 *Combating Weapons of Mass Destruction.* Similarly, while each Service has its own unique capabilities and structure, this concept uses a 'general force' as an example and does not endeavor to direct the specialties of any one service in particular.

The Central Idea

The Services support U.S. Government (USG) and Joint Task Force Commander (JTFC) efforts in CWMD operations by providing an agile and flexible response force capable of operating across the range of military operations (ROMO) despite the threat or presence of CBRN weapons. The general purpose force supports the overall DoD effort across the spectrum through the capabilities of WMD Force Projection, WMD Force Application and WMD Force Protection. This triad of pillars more accurately maps how the Services operate and develop capabilities at the tactical level. (see Figure 1.)

Service Framework supporting CWMD JIC

WMD Force Projection supports and demonstrates our nation's resolve to NonProliferation by supporting Diplomatic and Political-Military

efforts. This capability supports the WMD Threat Reduction Cooperation and WMD Security Cooperation and Partner Activities mission areas as identified in the NMS-CWMD. WMD Force Projection shapes the environment by creating conditions conducive to Service involvement in CWMD operations and assures our allies of our capability through Service involvement in multinational exercises, show of force operations and supporting other services or Other Government Agencies (OGAs) in activities that support USG objectives.

WMD Force Application imposes costs on the enemy or rogue actor through kinetic or nonkinetic denial of the ability to obtain or employ WMDs against our forces or allies as well as supporting efforts to eliminate WMD programs. This capability supports the WMD Elimination Operations, WMD Interdiction Operations and WMD Offensive Operations mission areas identified in the NMS-CMWD. When employed, WMD Force Application must be executed with precision yielding decisive results. Precision reduces collateral damage or harm to innocent civilians. Decisive results ensure that the enemy is unable to employ these weapons against our forces and allies.

WMD Force Protection applies materiel and non-materiel solutions to ensure mission accomplishment by denying the enemy the benefit of WMD use. Our Services must be capable of mission accomplishment in any climate and place. This includes hazardous environments that could be used in asymmetric conflicts. This capability supports the WMD Active Defense, CBRN Passive Defense and WMD Consequence Management mission areas identified in the NMS-CMD. WMD Force Application is applied through materiel means in the form of weapon systems, detection equipment, protective clothing, warning and reporting systems, decontamination equipment and other means of ensuring individual and unit survivability and mission accomplishment. Non-materiel means include doctrine, education, and individual and unit training that increase proficiency in operating in hazardous environments. Additionally, Services must have the capability to respond to and recover from WMD attack or release other than attack (ROTA) of toxic industrial materials as quickly as possible to restore combat operations and continue the fight.

To be effective in supporting and executing CWMD operations, our forces must be trained and equipped to apply the capabilities of WMD Force Projection, WMD Force Application and WMD Force Protection across the ROMO at any time. (See Figure 2.) It is important to remember that CWMD operations are not linear or sequential. Rather, they are continuous and often involve multiple overlapping efforts. Nor will Services always be involved in all aspects simultaneously. Commanders and staffs must be educated and trained in the tactical aspects of CWMD requirements and capabilities to ensure that their forces are technically and tactically prepared to provide the right support, in the right form, at the right time.

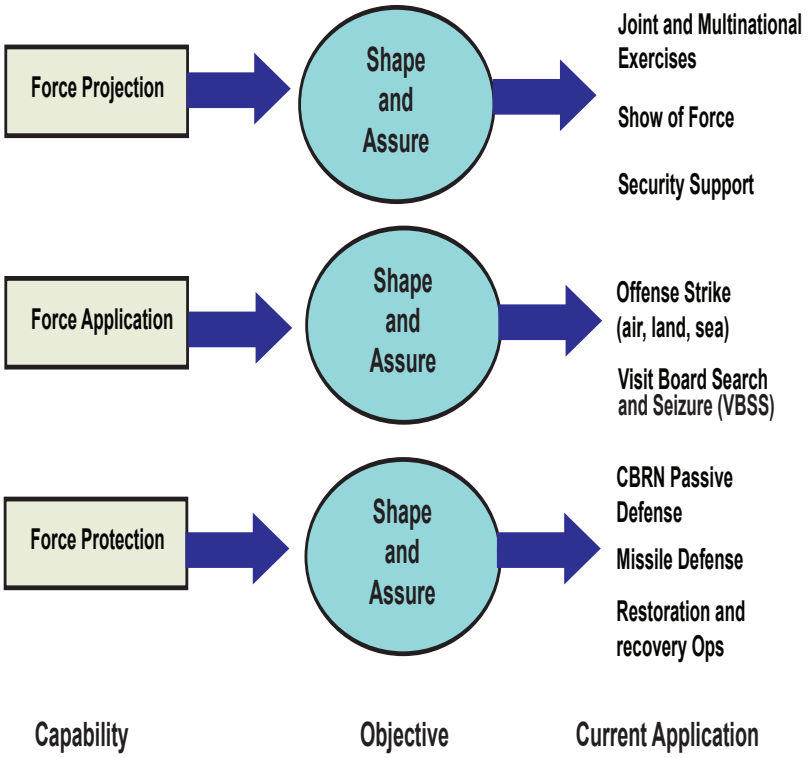

Figure 2. An example of Service Framework supporting CWMDJIC objectives using existing capabilities.

WMD Force Projection

WMD Force Projection establishes political-military and military-military relationships that demonstrate U.S. resolve and capability. It deters the use or proliferation of WMDs and encourages the support of nonproliferation of these devices and technologies. Services shape the environment to one where, if called upon to act in the nation's interests, the demonstrated capabilities of Services can more easily be brought to bear. The day-to-day operations of WMD Force Projection gain familiarity in forward operating areas while also fostering the international relationships that may alleviate diplomatic impediments to access. [1]

WMD Force Projection also assures our allies (and our enemies) of US resolve and demonstrates that Services are willing, capable and ready to respond to the threat of WMD use. Through the combination of diplomacy, military-military contacts, combined military activities and demonstrated skills, and effectiveness, we build allied and partner will and capacity for combined action. Assurance comes from the combination of demonstrated proficiency, reliable response capability and the dependability

gained through relationships formed over time.

The mission areas of WMD Threat Reduction Cooperation and WMD Security Cooperation and Partner Activities are more diplomatic in nature, but US Forces may be called upon to support or enforce them. Services conduct persistent forward engagement and are prepared to respond as the Nation's force in readiess. WMD Force Projection focuses on the support of Unified Action and holds the objective of shaping and assuring our allies and partners of Services' commitment and capability. These efforts are aided at the tactical level through military to military contacts, research and development agreements and similar efforts by subject matter experts (SMEs) assisting in arms control efforts.

Future WMD Force Projection capabilities will develop and enhance Service support to USG efforts. When developing plans and exercises, commanders will seek to incorporate CWMD-specific activities that encourage and enable allied and coalition participation, including participating in joint and multinational CWMD exercises if only in the capacity of a general purpose force. Commanders will also actively pursue opportunities to increase partner capacity through CWMD-related training and joint or coalition operations.

WMD Force Application

WMD Force Application encompasses the WMD Elimination, WMD Interdiction and WMD Offensive Operations mission areas. Here the focus is on the enemy and on either the capture or destruction of his ability to employ WMDs. Services may be called upon to employ combined arms, provide specialized forces or conduct forcible entry operations to accomplish this goal.

WMD Force Application may be kinetic or nonkinetic operations to detect, identify, disrupt and destroy an adversary's WMD assets, delivery systems and technologies. It requires refined intelligence and the ability to conduct complex operations in the urban littorals and other challenging environments. The objective is to impose costs on the enemy through the application of destructive or disruptive military capabilities under conditions that range from hostile to uncertain in permissive and nonpermissive environments. The demonstrated ability to accurately and precisely execute these actions may have a deterrent effect on WMD actors.

Elimination operations focus on the destruction of a WMD program (or WMD network) and require a high degree of operational or strategic level communication and coordination. The 2006 Quadrennial Defense Review Report identified the Army's 20th Support Command as the DoD lead for Elimination Operations.[2] At the tactical level, Services may be tasked by Combatant Commanders to seize, secure and isolate the facility or WMD materials and may also be called upon to support the technical operation through the initial identification of CBRN agents or precursors, intelligence and other actions that enable interagency activities. Forces should be fully prepared to provide support in whatever capacity (traditional or technical) the Joint Task Force Command (JTFC) may require.

Interdiction operations work to stop the "in transit" proliferation of WMD delivery systems, materials, or expertise through the tracking, interception and possibly the destruction of the assets to prevent their transfer or eventual employment. Joint Publication 3-03 *Joint Interdiction Execution* outlines the current joint doctrine for these operations and includes in the purposes for Interdiction the effectiveness of these operations for stopping the proliferation of WMD.[3] Services should be prepared to work with or alongside joint and coalition forces in the execution of these missions.

Offensive operations disrupt, neutralize, or destroy a WMD threat before it can be used, and deter subsequent use of such weapons. These operations may be performed by Services acting alone or as part of joint, coalition or host nation forces. They may be performed in permissive, semi-permissive or nonpermissive environments and, when directed, may be executed pre-emptively (in the absence of other hostilities) to destroy a known WMD threat prior to deployment. Additionally, planning for WMD Offensive Operations must also consider the type of agent and the possible need to conduct subsequent WMD Consequence Management actions to reduce the hazard created by any residual contamination.

When the decision has been made to impose costs through WMD Force Application, the force accomplishes the task through precision engagement, ideally with minimal collateral damage.Further, WMD Force Application plans for CWMD operations will include CBRN passive defense capabilities to protect the force and may require WMD Consequence Management contingency plans to mitigate any residual contamination resulting from the operation.

Future development of WMD Force Application will include increased ability to support the site characterization aspect of Elimination Operations; the ability to perform on-the-move stand-off CBRN detection, and packaging and transporting of captured materials in support of Air, Land and Sea Interdiction Operations; and, increased targeting accuracy and munitions selection with special consideration for WMD in support of Offensive Operations.

WMD Force Protection

WMD Force Protection is the most familiar aspect of CWMD and encompasses the mission areas of WMD Active Defense, CBRN Passive Defense and WMD Consequence Management. Here the focus is on the protection of the force and the ability to sustain and accomplish the mission, given that we cannot fully expect to defeat the threat through WMD Force Projection or Force Application. Forces in the field must maintain freedom of action on the battlefield unconstrained by CBRN hazards. Dominance is achieved through the ability to initiate operations, defend against attack, logistically sustain operations, and to restore operations where CBRN contamination may be involved. These three areas must be linked

to ensure the force has overlapping protection throughout efforts to mitigate the CBRN hazard. WMD Force Application involves materiel and non-materiel capabilities to protect forces, equipment and installations from WMD use and to speed recovery operations. Intelligence supports WMD Force Application through collection efforts regarding enemy weapons capability, disposition and intent, and by identifying industrial hazards in the area of operations. These actions work together to deny the enemy any benefit of WMD use by reducing the forces's vulnerability attack and by minimizing the effects of CBRN hazards on the force.

WMD Active Defense includes action taken to destroy, nullify or reduce the effectiveness of hostile air and missile threats against friendly forces and assets. This task includes the use of aircraft, air defense weapons, electronic warfare, and other available weapons which are used to prevent enemy use of airspace through fire potential or other means without direct attack of air targets. When elements of the JTF employ WMD Active Defense assets, additional consideration must be taken to anticipate possible contamination for those who may be affected by successful engagement against enemy WMD weapons and systems. Warning those in the possible area of contamination and the availability of WMD Consequence Management assets are additional planning considerations.

CBRN Passive Defense measures reduce the effect of CBRN hazards on the force. It protects forces and critical infrastructure through the application of multiple disciplines that detect, identify, and characterize CBRN contamination, warn and report the presence of contamination, and physically protect personnel, equipment, military working animals and facilities from hazards. Throughout the DoD, Passive Defense is developed in four operational elements: CBRN Shape, CBRN Sense, CBRN Shield and CBRN Sustain. CBRN Shape provides the common operational picture that contributes to the overall awareness of threats and hazards. CBRN Sense provides the means to detect, identify and quantify hazards. CBRN Shield applies a layered approach to physically protect the force (i.e., suits, boots, gloves, masks). CBRN Sustain mitigates the hazard (e.g., decontamination) to ensure that the force is able to continue operations and accomplish the mission unimpeded. Passive defense can be challenging to implement, given the proliferation of different CBRN hazards and the need to address both the protection of the general force and the more sophisticated needs of specialized reconnaissance forces. JP 3-11 *Operations in a CBRN Environment* provides additional guidance on the application of CBRN Passive Defense equipment and techniques.

WMD Consequence Management is the ability to respond to and recover from a WMD event. These operations facilitate a return to stability by minimizing or mitigating the effects of hazards in order to provide timely assistance to affected forces, save lives and reduce environmental damages. Services possess WMD Consequence Management capabilities primarily to ensure unit survivability and mission accomplishment. As with any other military capability, DoD may be called upon to provide WMD Consequence Management support for domestic or foreign events. During a domestic event (on the U.S. Homeland or territory), the Department of Homeland Security is the lead and DoD supports as directed. During events on foreign soil, DoD supports the Department of State. DoD leads WMD Consequence Management when directed or in the absence of other civilian authority. WMD Consequence Management includes the ability to function in exotic environments with reduced oxygen or levels beyond Immediately Dangerous to Life and Health (IDLH). DoD is not a 'first responder'; such as firemen, emergency medical technicians or police. Rather, DoD capabilities can provide much needed personnel, equipment and logistics to support the ongoing hazard mitigation effort. WMD Consequence Management operations often support the transition to interagency or other civilian authority for the continued mitigation effort.

Bases and stations must rely heavily on WMD Force Protection preparation and efforts. Installations employ a full range of CBRN Passive Defense and WMD Consequence Management capabilities to protect the force from the effects of WMD. Advanced bases may need to consider WMD Active Defense measures coordinated with tenant activities. Memorandums of Understanding (MOUs) and Memorandums of Agreement (MOAs) along with coordinated training with local, joint, coalition and/or host nation governments in CBRN incident response will enhance first responder capabilities and increase the ability to recover and respond from attack. Services should seek out these opportunities to train and build command relationships.

Future capabilities in WMD Force Protection will enable the Service to prevail in any environment. Continued analysis and requirements development efforts will focus on measures to detect, track, target and destroy incoming WMDs using a networked array of intelligence sensors and detectors that tie into the common operational picture. By ensuring that all operational units possess the ability to improve situational awareness by identifying and characterizing any CBRN threat, forces will be able to communicate changes in the operational environment across the networked battlefield in real-time. Forces will employ technical reachback to aid in detection, identification and quantification efforts to characterize the threat or hazard. Operational tempo will be maintained through lighter, more durable individual and collective protection and a layered contamination mitigation plan that fully utilizes a robust, yet flexible, logistical support network. Individual and unit training integrates CWMD tasks and missions into exercises and operations at all levels of command. To aid in achieving this future-state commanders and staffs are educated in CWMD as part of their professional military education continuum; especially in understanding the assets and resources of DoD as a whole.

End State

While the CWMD mission areas are presented as a continuum from NonProliferation through WMD Consequence Management, they are not performed "sequentially". Instead, numerous events contributing to the overall effort may be occurring simultaneously or in a mutually supportive fashion in any given geographic region. (See Figure 3.) Services may be tasked to contribute to the overall CWMD strategy of the Geographic Combatant Commander through tactical-level action that may not reflect the overall effort to destroy a network.

CBRN defense is a participant to the overall effect but is not the sole source of information or solution the problem. CBRN defense capabilities contribute to the overall execution of all CWMD tasks but do not solely define a CWMD mission. The staff remains the focus of effort. The commander remains the decision-maker. The objective remains the accomplishment of the mission. WMD Force Projection, WMD Force Application and WMD Force Protection are supported by the cumulative efforts of the entire staff. Intelligence, Logistics, Fires and Operations (including CBRN) must be timely, scalable and coordinated through a flexible command and control network. Staffs at all levels must be aware of the CWMD mission areas and the Service functions that support them. Staffs should become well versed in the CWMD JIC, its objectives and its methodologies to better understand the needs of the JTFC and how Service capabilities assist in mission accomplishment.

Ultimately, this concept introduces no new tasks. Rather, it exemplifies how existing Service capabilities support the ongoing DoD strategy in a way that better enables the Services to apply the limited resources of personnel, time and equipment. The core capabilities of each Service fully support this concept can be applied to stopping the development, transfer and use of weapons of mass destruction.

Vignette: MAGTF Operations and Combating Weapons of Mass Destruction

The year is 2018. Operations in the Middle East have stabilized to a steady state wherein the force commitments are reduced and combat advisors conduct routine capacity building missions in support of indigenous military forces. However, Africa has continued to experience steady economic decline with crushing poverty, government corruption, epidemic level medical emergencies, and ethnic conflict creating conditions that threaten US interests and regional security. The U.S. Government has taken the lead for the international community in an effort to bring the continent out of this state of continuous crisis.

Learning of rogue actor attempts to develop new bases of operation for advanced weapons of mass destruction (WMD) development in East Africa, the U.S. Government invests in *WMD Force Projection* to deter proliferation and assure our partners of our commitment. The U.S. leads a NATO effort to broker the "East African NonProliferation Agreement" (EANPA), in which signatories from several nations agree to identify dual-use technology facilities, enter the names of scientists and specialized technicians into an international database, and to deny agencies, foreign governments and industries from using their sovereign land for the development of WMDs. This threat reduction cooperation effort is augmented by a NATO guarantee to aid these nations in developing their own ability to deny, defeat, deter and defend themselves from proliferators and WMD use through political-military education, training and materiel support (where needed).

As part of a whole of government approach to support the EANPA, the Marine Corps assigns 1st Battalion 2nd Services (1/2) as a Security Cooperation Marine Air-Ground Task Force (SC-MAGTF). The battalion acts as the core of the SC MAGTF and is supported by an attached composite squadron, a detachment from Service Logistics Group 2, digital and satellite communications assets provided by 8th Communications Battalion, military police, intelligence, information operations, and civil affairs detachments. Following its pre-deployment training which included combat training and specialized training for security cooperation, SC MAGTF 1/2 deploys to a forward operating base at Rota, Spain where the battalion command post is established. The main body of the battalion has been preceded by an advance party who conducts liaison with MARFORAF, AFRICOM, and theater Service Advisors provided by the Defense Threat Reduction Agency. The SC MAGTF is seen as a prime candidate for strategic communication that demonstrates U.S. resolve and commitment to the EANPA.

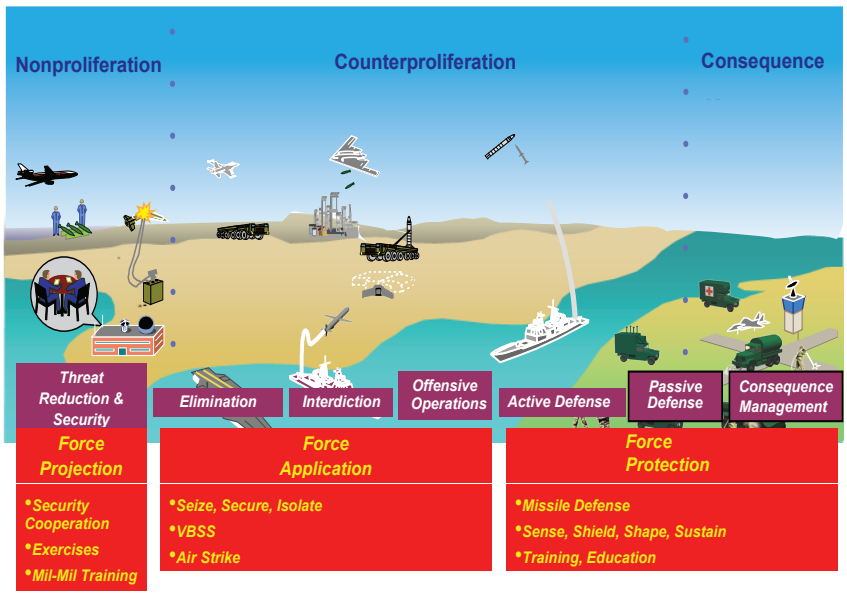

Figure 3. Service Framework to Combat WMD supports all existing CWMD mission areas.

The battalion commander and select members of his staff deploy to inspect and supervise the operations of the subordinate units. They also support the SC MAGTF mission by deploying to selected high visibility training and exercise events. The disaggregated elements of SC MAGTF 1/2 conduct a range of sustained bi-lateral training, foreign internal defense, and partnership capacity building activities including: training with the Djiboutian military aimed at professionalizing the small country's ethnically fractious military, bi-lateral training with a composite African Union (AU) battalion destined for peacekeeping duty in Somalia, and combined CBRN Consequence Management exercises with Ethiopia, United Nations forces, and other non-governmental organizations aimed at preventing loss of life due to industrial accidents as the nation continues to develop modernization efforts outside of its capital.

Three months into the battalion's deployment, a crisis erupts in a small East African country. Acting on Defense Intelligence Agency (DIA) and National Security Agency (NSA) reports, East Africa receives increased and persistent intelligence focus which reveals possible chemical weapons development in a textiles plant owned by the Argus Corporation, a company which also is suspected to be supporting a rogue actors engaged against US forces in Afghanistan. AFRICOM and CENTCOM work together seeking to disrupt and destroy the WMD node in its entirety. Each COCOM begins independent efforts to identify personnel, funding resources, technology development levels, logistical support, delivery means, intelligence/surveillance/ reconnaissance (ISR) capabilities, command and control mechanisms and authorities. The host nation (HN) government aids in the effort by authorizing unprecedented access to records and communications involved with the Argus facility in accordance with the EANPA.

Believing that sufficient intelligence exists to support that this facility is being used for WMD development (and concerned that internal government corruption may lead to having the plans known to the proliferators) , HN nationalizes the facility and authorizes a US lead multinational military action to seize all property and personnel. Already having a WMD Force Application plan in place, SC MAGTF 1/2 leads the coalition effort to seize, secure and isolate the facility, and to stabilize the situation to a sufficient degree until a Marine Expeditionary Unit (MEU) can arrive on station for relief. The Marines meet resistance from the facility security personnel but are able to suppress the small arms fire with minimal casualites to either side.

Joint Task Force Elimination (JTF-E) formed in advance and deployed to a forward staging area in Rota, Spain arrives the next day to begin the systematic elimination of the WMD program within in this nation. Technical reachback is employed to support chemical identification and translation processes. Within a day, JTF-E confirms the intelligence reports of chemical agent production; identifying precursor agents for a binary chemical weapon being developed alongside textile chemicals in a separate part of the facility. Documents and human intelligence reveal that a shipment of the agents was currently on its way via a handysize freighter ship (The Fruit of Allah- Afghani flag) to the port of Aden in nearby Yemen. CENTCOM receives a SecDef directive to seize the ship in international waters and to interdict the transfer of the chemicals. CENTCOM tasks Expeditionary Strike Group 2 to conduct visit, board, search and seizure (VBSS) operations and, if possible, locate the agents and confirm their presence. JTF-E stands by to assist, if required, as technical reachback.

The strike group locates and blocks the Fruit of Allah in international waters and deploys elements of the 26th MEU to execute the VBSS operation. The crew offered no resistance and the captain claimed no knowledge of any illegal chemicals aboard. In the non-hostile environment, the MEU deploys a CBRN reconnaissance team equipped with a Level B protective ensembles and detection equipment capable of identifying industrial chemicals. Once the containers matching the shipping labels identified at the Argus facility were located, the toxic industrial chemical identification equipment confirmed the presence of carefully packaged chemical agent precursors but no launching devices.

Continued DIA and NSA operations in Afghanistan corroborated corporate reports of "missing fruit" to the expected date and time of the ship's arrival in Yemen. The intelligence trail leads to a company operating from a factory on the outer edge of a small village along the Afghanistan-Pakistan border; an area known for terrorist activity. Theater Special Operations Command (TSOC) Reconnaissance assets deploy near the village and confirm the presence of chemical protective equipment and mobile launch vehicles. It is believed that the rogue organization is planning to use chemical weapons to make up for their diminished numbers after years of guerilla warfare.

Under direction from CENTCOM and Commander, International Assistance and Assurance Force Afghanistan, the 4th Brigade Combat Team begins offensive operations against the rogue organization to deny the enemy use of the weapons, defeat them in place, deter any future use and defend US forces and allies from WMD use. The 82nd Airborne Division conducts a ground assault supported by an initial air attack with continued security.

WMD Force Application planning encompasses the active defense, passive defense and WMD Consequence Management aspects of the effort. The air attack plan is to execute the operation with precision via rotary wing aircraft, carefully identifying the proper munitions to ensure both the destruction of the agent and to minimize collateral damage and residual contamination that could threaten civilians. The ground assault force will be augmented by air defense weapons systems, CBRN protective equipment and mobile CBRN reconnaissance platforms. A mobile-loaded decontamination team is put in support.

Discovering the massing U.S. forces, the rogue organization scrambles into action for an attack and manages to launch a

single chemical missile towards the American ground forces even as the air attack obliterates the compound. The assault force successfully detects the inbound missile and utilizes its active defense systems to engage and destroy it. Observing the destruction of the terrorist camp, the unit then deploys Unmanned Aerial Vehicles (UAVs) to reconnoiter the facility for survivors without exposing personnel to any possible contamination resulting from the attack on the chemical storage facility. Even though the unit was deployed upwind from the facility to reduce the possibility of contamination, passive defense activities, such as chemical detectors and alarms, and maintaining Mission Oriented Protective Posture Level 2 (MOPP 2), are engaged for WMD Force Application.

The ground force then deploys a CBRN Reconnaissance team and the mobile decon section to the missile crash site to conduct Consequence Management Operations to mitigate any contamination and thus reduce any residual hazard to the force and any civilians who may come through later. The force secures the site (at a safe distance) dressed in MOPP 4 and ensures safe passage for the CBRN and EOD teams. CBRN Reconnaissance team members, dressed in Level B protective suits and equipped with toxic industrial chemical detectors locate the missile remains and confirm that the canisters containing the chemical payload remain intact. While accompanying EOD team members (also in Level B) render safe the rocket system, the CBRN Reconnaissance team carefully packs the canisters for shipment and transfer to inbound JTF-Elimination personnel for forensic analysis. Care is taken to begin a chain of custody for any future legal action and to record identifying marks from the missile parts to assist in assigning attribution for any who may have aided in supporting the WMD program. Once the canisters have been shipped and the CBRN Reconnaissance team confirms that there was no residual chemical contamination in the facility or village, the unit turns over control of the area to civilian authority provided by the Host Nation and redeploys to its next engagement.

Within two weeks following this operation CENTCOM and DIA intelligence resources were able to use the forensic evidence to identify financial resources and technical experts related to the rogue organization and their attempted use of WMDs. These leads later yield arrests that strike a major blow to several terrorist splinter groups attempting to develop WMD systems for a coordinated attack against U.S. forces in Afghanistan, Africa and Europe. This successful operation saved countless military and civilian lives.

Conclusions

This vignette has shown how Services can successfully support U.S. Government objectives and the Joint Task Force Commander (JTFC) to execute combating weapons of mass destruction missions. Within less than 5 days, three Services, functioning at various levels and located in two different geographic combatant commands, worked in unison to support or execute the 8 mission areas to combat weapons of mass destruction and destroy the rogue actor's WMD network through the application of WMD Force Projection, WMD Force Application and WMD Force Application.

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ENDNOTES

1. NMS-CWMD page 15
2. 2006 Quadrennial Defense Review Report page 52
3. Joint Publication 3-03 Joint Interdiction Execution

The Department of the Army's Role in Response to a Domestic Bioterror Attack

LTC Mitchell L. Wise
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History of National Terrorism Response Policy

For the past three to four decades the United States (U.S.) has faced an increasing threat of terrorist attack. Although the horrific scale of the World Trade Center and Pentagon attacks of September 11, 2001 have not been repeated in the U.S. mainland, there can be no doubt that terrorists, with any number of political and religious agendas, are still targeting the U.S. homeland. The arrests in October 2009 of members of an Islamic terrorist organization in New York City as well as the jihadist rampage by MAJ Nadal Hasan at Fort Hood in November 2009 and the failed 2010 Times Square car bombing serve as stark reminders that large scale attacks continue to be planned and executed in the U.S. The growing tensions between the U.S. and the Islamic Republic of Iran over its nuclear weapons development program should also cause great concern. Any military intervention by the U.S. or Israel against Iran will almost certainly precipitate a response in the form of terrorist attacks worldwide, including the United States. Although terrorism is largely treated as a criminal activity by the current administration, the U.S. Army is likely to play a key role in responding to any large scale attack in the homeland, especially those involving weapons of mass destruction. This article will address the role of the Department of the Army (DA) in response to such an attack, with particular attention to biological weapons.

PDD-39 1995 (U.S. Policy on Counterterrorism) and Nunn-Lugar-Domenici Act

Shortly after the Oklahoma City bombing in March 1995 and with the first World Trade Center attack as well as the Aum Shinrikyo sarin (nerve gas) attack in Tokyo in recent memory, President William Clinton issued Presidential Decision Directive 39. PDD-39 delineated the responsibilities of the various Federal Agencies in countering terrorism and provided guidance for mitigating the possibilities of such attacks. It also outlined measures to manage their consequences. This directive led directly to the formulation, in 1996, of Public Law 104-201: The National Defense Authorization Act (also termed the Nunn-Lugar-Domenici act for the three Senators that introduced the legislation). The Nunn-Lugar-Domenici act called for Federal Assistance, primarily from the Department of Defense (DOD), to local, state and federal first responders for training to respond to a WMD event. At the time the Department of Energy (DOE) had a radiological response team, but units specifically trained and equipped for a large scale chemical or biological terror attack were lacking. The act called on the DOD to create at least one rapid response team:

"...capable of aiding Federal, State, and local officials in the detection, neutralization, containment, dismantlement, and disposal of weapons of mass destruction containing chemical, biological, or related materials."[1]

Pursuant to this act the Deputy Secretary of Defense assembled a Tiger Team to formulate how best to comply with this mission.

After an in depth analysis of DOD capabilities the Tiger Team identified the U.S. Army Technical Escort Unit (TEU) and the U.S. Marine Corp Chem-Bio Incidence Response Force (CBIRF) as having some of the desired capabilities. Although these teams were deemed adequate for large public events that might attract the interests of terrorists, such as the 1996 Olympic Games in Atlanta, they were inadequately focused for an unforeseen local catastrophe. The Tiger Team also surmised that the DOD had certain unique laboratory capabilities such as the AMC Treaty Laboratory, The U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID), and the Edgewood Research, Development and Engineering Center (ERDEC). All of which are capable of dispatching mobile laboratories world wide. But what was desired were multiple, highly mobile units dispersed throughout the United States capable of fitting into the National Response Plan (later to evolve into the National Response Framework) whose mission would focus on Civil Assistance in the event of a domestic WMD event.

The National Guard's long history in support of State Government in natural disaster response was considered an ideal starting point. The National Guard occupies a unique position in the DOD as it can function either as a State asset under the authority of the Governor and the Adjutant General or it can be mobilized by the President in the event of a National Emergency.

Initially termed Rapid Assessment and Initial Detection (RAID), these units were task organized for the specific mission of deploying to a site of a catastrophic natural or man-made disaster (e.g. WMD) and to provide support in assessing

the nature of the threat and to identify potential nuclear, chemical or biological agents. Presidential Decision Directive (PDD) 62 (Combating Terrorism) called for 10 RAID teams to be fielded, one in each of the FEMA regions. This program was subsequently expanded to provide at least one team in each of the U.S. states and territories as RAID teams transformed into WMD-Civil Support Teams (WMD-CST).

Posse Comitatus Act

To fully understand the role (and restrictions) of the DA in Homeland Defense one must recognize the stipulations of the Posse Comitatus Act of 1878. This statutory regulation limits the role of Federal Uniformed Services in responding to civil disturbance. It was enacted in the aftermath of the American Civil War, interestingly, as a political compromise with Southern members of congress to settle the hotly disputed 1876 presidential election. In essence, this Act prohibited the use of the Army in an active law enforcement role, such as it performed during the Reconstruction Era following the Civil War. The Act was extended to include the U.S. Air Force in 1956 and by DOD regulation it also encompasses the U.S. Navy.

The U.S. Coast Guard and National Guard (under the direction of the Treasury Department or operating under state authority pursuant to Title 32 of the U.S. Code respectively) are exempt from Posse Comitatus. Only when these agencies have been federalized do they fall under this regulation. Although intended to prevent the use of military forces for civil law enforcement, a concept most Americans would likely agree with, the law has been circumvented through various mechanisms in recent years.[2]

The transnational nature of many terrorist organizations, who aren't constrained by sovereign borders or recognizable governments, combined with the blurring of acts of war with criminal acts within the US borders, challenge the utility of the Posse Comitatus Act in 21st century America.[3] Nevertheless, many activist groups vigorously uphold the provisions of this act and work stridently to prevent any circumvention of its intended purpose. Any federal military assistance to civilian authorities must take the provisions of Posse Comitatus into account.

CST Civil Support Team Member in Level A gear.

Biodefense in the 21st Century

In 2002, after the massive terrorist attacks in New York and Washington DC, President George W. Bush formulated a new strategy to combat terrorists from implementing weapons of mass destruction. This strategy, articulated as the National Strategy to Combat Weapons of Mass Destruction 2002, outlined three principal pillars: counter-proliferation, nonproliferation and consequence management. These pillars are to be integrated with four cross-cutting functions: intelligence collection and analysis, research and development, bilateral and multilateral cooperation, and targeted strategies against hostile states and terrorists. This document also charged the newly formed Department of Homeland Security to:

"*coordinate all federal efforts to prepare for and mitigate the consequences of terrorist attacks within the United States, including those involving WMD*".[3]

This represents a departure from the previous administration's policy in which the FBI, under the Department of Justice, would be the lead agency in response to a domestic terrorist attack. Under the new guidance, the Federal Emergency Management Agency (FEMA) is the lead federal agency for consequence management while the FBI still leads the investigation. In 2004 President Bush specifically addressed the threat of bioterrorism with his Homeland Security Presidential Directive 10 titled "Biodefense for the 21st Century". This document clearly delineated the lead agencies for various aspects of our defense to biological terrorism. It also provided the impetus to start several new homeland defense programs related to biological weapons including: BioShield (a program to stockpile medical resources such as vaccines and antibiotics), BioSense (a program to monitor infectious disease outbreaks) and BioWatch (a program to emplace bioagent detection systems in "critical" locations). In the event of a domestic bioterror event the DOD largely has a supporting role to assist whatever lead federal agency is involved. The assets available from the Department of the Army will be described in some detail below.

The Bioterror Threat

Of all the potential WMDs, the threat posed from bioterrorism is un-doubtably the least understood.

> *"…we are launching a new initiative that will give us the capacity to respond faster and more effectively to bioterrorism or an infectious disease, a plan that will counter threats at home and strengthen public health abroad."*
> President Obama, State of the Union Address, Jan 27, 2010.

The quote by President Barack Obama, above, refers to the United State's new strategy to reduce

biological threats by "improving global access to the life sciences to combat infectious disease regardless of its cause; establishing and reinforcing norms against the misuse of the life sciences; and instituting a suite of coordinated activities that collectively will help influence, identify, inhibit, and/or interdict those who seek to misuse the life sciences".[4] President Obama clearly illustrates, there is much concern about the feasibility of terrorist organizations to mount a biological weapons attack. Several reports indicate considerable interest by an Islamic terrorist organization, Al Qaeda, to acquire biological agents.[5,6]

However, the evidence for these reports and the feasibility of these loosely knit transnational organizations to actually acquire and effectively employ a biological weapon has been severely questioned.[7] The actual use of bioterror in modern times has been rather limited. Two of the most significant events in the U.S. were the anthrax attack on the senate offices of Senator Tom Daschle (South Dakota) and Patrick Leahy (Vermont) along with several major news outlets, including collateral contamination of numerous Postal Service mail rooms in September of 2001. Also the Rajneesh religious cult attempt to sway local elections in The Dalles, Oregon by incapacitating potential voters through contamination of local diners' salad bars with a virulent strain of salmonella. Although in terms of numbers of fatalities these bioterror events were comparatively small both attacks point out two salient features of bioterrorism: (1) they tend to spread fear far in excess of the harm actually done and (2) the very slow pace in which the actual attack is realized (relative to, for example, a high explosive device).

Department of the Army Operational Support

At the time of the Tiger Team assessment of DOD bioterrorism response capabilities there were two specifically trained and equipped units, the U.S. Army Technical Escort Unit (TEU) and the U.S. Marine Corps Chem-Bio Incidence Response Force (CBIRF).

The U.S. Army TEU was originally developed during World War II to provide a specially trained unit to transport chemical weapons and other hazardous materials. The TEU was subsequently employed in post-war Europe to transport captured German chemical munitions, later they played a key role in the disposal of U.S. chemical weapon stocks. As the pace of chemical weapons demilitarization increased, subsequent to enactment of the Chemical Weapons Convention, the U.S. Army's TEU took on the role of the DOD's premier experts in chemical weapons identification and decontamination. This role has subsequently expanded to include biological weapons.

In 2004 the U.S. Army transformed the TEU, an Army Materiel Command Table of Distribution and Allowances unit, into a Forces Command (FORSCOM) Table of Organization and Equipment battalion, the 22nd Chemical BN (Technical Escort). In 2005 the Army activated a second TE BN, the 110th Chemical BN (Technical Escort). Each battalion has the typical S-1 through S-4 and command staff sections, along with maintenance, medical, communication, and chaplain sections. The operational component consists of a single Technical Escort Company composed of Chemical, Biological, Radiological, Nuclear, high-yield Explosives Response Teams (CRT). The CRTs can assist the combatant commander in the planning for sensitive site exploitation for WMD – Elimination operations. They have the capabilities to conduct Sensitive Site Exploitation (SSE) on identified and suspected WMD sites (with limited disablement), perform presumptive identification of chemical and biological warfare agents, sample, package, transport and escort WMD materials. Additionally the CRT can conduct render safe and explosive threat mitigation with its organic Explosive Ordinance Disposal (EOD) capability.

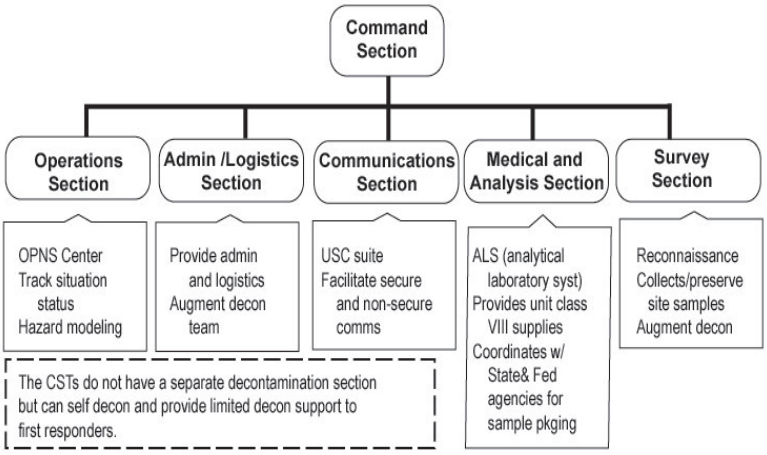
The CRT, as currently configured, is capable of world wide deployment in support of military and civilian crisis management. With security support from a combatant command the CRT can operate in the entire spectrum of environments from permissive to hostile and CBRN hazardous. The CRTs have only limited self decontamination capabilities and do not offer full spectrum EOD support, due to team size limitations. The CRTs may also require external maintenance support for some of their commercial off-the-shelf (COTS) equipment. Some of the high tech CBRNE identification and render-safe equipment available to the CRTs include the HazMatID, the Ahura, the R.A.P.I.D.®, the CBRN Unmanned Ground Reconnaissance (CUGR) robot, the ANDREX X-ray, and the Portable Isotopic Neutron Spectroscope (PINS, a device using neutron radiation to non-intrusively identify explosive or chemical agents inside a closed container such as an artillery shell).

Also mentioned in the Tiger Team assessment was the Marine Corps CBIRF. Although not a component of the Department of the Army, this force is closely aligned with homeland security and is included in the task organization of the CBRNE Consequence Management Response Force (CCMRF, see below). The CBIRF was originally formed in 1996 and consists of about 375 marines. Originally stationed at Camp Lejune, NC they are now headquartered at Indian Head, MD. The CBIRF is task organized to respond to crisis management as well as consequence management in the event of a chemical or biological event.

The CBIRF, which is built around 500 Marines, Sailors, civilian employees and contractors, provides the following consequence management capabilities: agent detection and identification, casualty search and extraction, technical rescue, personnel decontamination, emergency medical care and stabilization of contaminated personnel.[8]

The reconnaissance team is equipped with an array of DOD and COTS nuclear, chemical, and biological agent detection as well as individual protective equipment ranging from Level A through D chemical protective garments.

The decontamination element, when fully established, has the capacity of up to 225 ambulatory personnel per hour and up to 30 response force personnel hour.



Civil Support Team (CST) Organization

The medical team, built around an emergency or occupational medicine doctor, physicians assistants, and corpsmen, is capable of operating in Level B-D and initiating treatment in either the hot or warm zone. All these team members have specialized training for treatment of chemical and biological warfare victims.

Casualty search & extraction and technical rescue teams are capable of locating and removing victims from a contaminated areas as well as operating in confined space and collapsed structure environments. Both teams are Level B trough D capable.

CBIRF's C4I capability allows them to communicate between Title 10 and 32 organizations as well as local, state and federal agencies. Additionally, they have and EOD detachment designed to mitigate threats for continued down range operations.

Civil Support Team (CST)

The National Guard (NG) WMD Civil Support Teams (WMD-CST) developed as a result of the DOD Tiger Team's assessment, now number 57. They are now commissioned in each of the fifty states (California has two) and the District of Columbia, Guam, Puerto Rico, and the Virgin Islands. These units are federally funded but, unless federalized by the President, are under operational control of their respective State Governor and Adjutant General. Each team is commanded by a Lieutenant Colonel and consists of 22 full time Active Guard Reserve (AGR), Active Army and Air National Guard personnel. The units are organized into an Operations team, Administration and Logistics team, a Communications team, a Medical team and a Survey team. According to Field Manual 3-11.22 (Weapons of Mass Destruction Civil Support Team Operations Manual):

> *The mission of the WMD-CST is to support civil authorities at domestic CBRNE incident sites by identifying CBRNE agents and substances, assessing current and projected consequences, advising on response measures, and assisting with appropriate requests for additional support.*

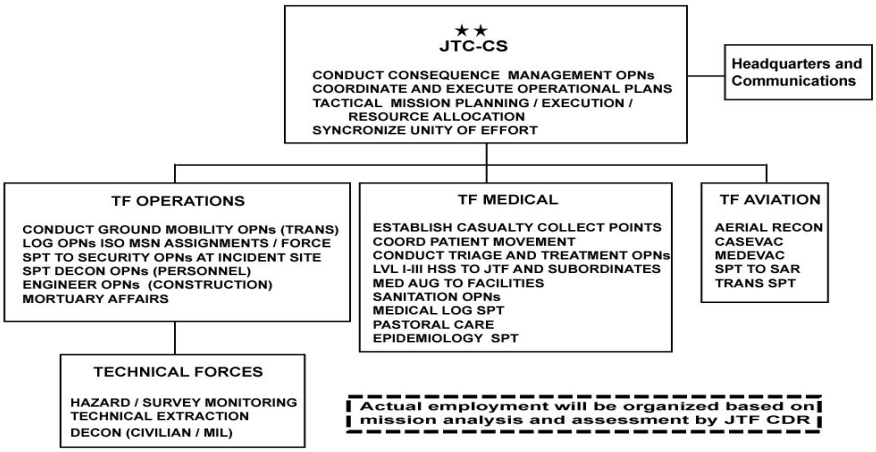
Using largely non-standard equipment, these units are well equipped to assess and identify chemical, biological and radiological contamination. The survey team members have Occupational Safety and Health Administration (OSHA) approved level A and B personal protection equipment. Each unit has a mobile analytical laboratory system that combines standard DOD detection equipment with the latest COTS chemical and bio-agent detection equipment[9] to provide rapid (presumptive) field identification. They are also equipped with a unified command suite (UCS) vehicle housing ultra high frequency (UHF), very high frequency (VHF), high frequency (HF), FM and digital communications equipment. The UCS can also set up a local area network with other first responders and provide secure digital communications in remote areas. Some of these communication capabilities are duplicated in the advanced operations (ADVON) vehicle and are highly prized by first responders in many emergency situations.

CBRNE Enhanced Response Force Package (CERFP)

The CERFPs are modeled after the U.S. Marine Corps CBIRFs and are a component of the National Guard. Created to augment the capabilities of the CST, they were initially fielded in each of the 10 FEMA regions in the United States. At present there are 17 CERFPs certified by the National Guard Bureau.[10] Each CERFP is composed of four elements: command and control (C2), search and extraction, decontamination and medical. These elements are drawn from existing NG units, the extraction element usually coming from an Engineer Battalion, the decontamination element from a Chemical Company, the Medical element typically from an Air National Guard Medical unit, the C2 element can be drawn from a variety of operational NG units. Each CERFP consist of 180-200 personnel and provide immediate support to the CSTs in the event of a mass casualty event resulting from a WMD. Like the CSTs, the position of these CERFPs under the National Guard Bureau allow implementation of their assets either under Title 32 provisions by the State Governor or, if Federalized, under Title 10 and the DOD.

CBRNE Consequence Management Response Force (CCMRF)

At the upper end of the response forces programmed to respond to a civil support mission is the CBRNE Consequence Management Response Force (CCMRF). This is a brigade size unit (approximately 2,900 - 4,700[11] personnel depending on mission) that is organized as a joint task force to provide: command and control, incidence assessment, search and rescue, medical, decontamination, aerial and ground transportation, general logistic support as well as security forces (specifically allocated for force protection). Under the



CBRNE Consequence Management Response Force (CCMRF) Organization

command of Northern Command (NORTHCOM), the first CCMRF was activated in October 2008 at Ft. Stewart GA and was designed to deploy as a C2 HQ with three force packages: Operations, Medical, and Aviation. The CCMRF are the first Title 10 asset dedicated to respond to a large scale CBRN event. They have a goal of being on-site within 24-96 hours of notification.

The operations force package will provide nuclear, chemical and biological survey capabilities, equipment and personnel decontamination, rescue and extraction expertise to include engineer assets, transportation capabilities and a security force. The technical forces associated with the operations force package come in the form of a U.S. Marine Corps CBIRF, a U.S. Army Chemical Decon company, an U.S. Army Chemical Reconnaissance platoon and a Chemical BIDS (biological identification and detection system) platoon. A Defense Threat Reduction Agency (DTRA) Consequence Management Advisory Team (CMAT) is also assigned to the CCMRF. The operations force package also has a mortuary affairs section.

The medical force package, including a medical headquarters and an emergency deployable medical headquarters (EMEDS), will provide triage and treatment, hospital augmentation, essentially the full array of medical care associated with a brigade medical team. The aviation force package provides helicopter airlift capabilities to facilitate survey and reconnaissance missions as well as MedEvac. In essence the CCMRF is similar to a combat support force with logistics capabilities specialized for operations in a CBRNE environment. Additionally, the search and rescue personnel are trained to the standards of the National Fire Protection Association.

CBRNE Headquarters (20th Support Command)

A CBRNE Headquarters, currently designated the 20th Support Command, activated in October of 2004 as a major subordinate command to provide a "one-stop-shop" for FORSCOM CBRNE response capabilities. Composed of three Explosive Ordinance Disposal groups (52nd, 71st, and the 111th (USAR)), a chemical brigade and an asymmetric warfare regiment, the 20th Support Command provides major combatant commands their required CBRNE support world wide.[12] In addition they support homeland defense in the event of a WMD attack. The 20th Support Command also functions as the core element of the Joint Task Force for Eliminating WMD (JTF-E). Within the structure of the 20th are three conventional EOD groups consisting of ten battalions based throughout the United States. In addition there is the 21st Ordinance Company specifically designated for WMD disposal. The 48th Chemical Brigade is composed of five Chemical battalions including the 22nd and 110th TE BNs. The 20th Support Command also possesses a unique "CBRNE Analytical and Remediation Activity (CARA)".

The CARA is an all civilian DOD organization consisting of four sections, two of which are the Remediation Response Sections (RRS). In order to provide a more immediate transcontinental response the RRSs are located at Aberdeen Proving Ground Maryland, and at Pine Bluff Arsenal, Arkansas. There is an aviation section, for Continental U.S. (CONUS) operations, with the capability to transport chemical surety escort teams. There is also a Mobile Expeditionary Laboratory (MEL) section capable of deploying highly mobile field confirmatory laboratories for analysis of nuclear, chemical and biological warfare agents. These MELs offer a light and heavy configuration. The light configuration can be packaged in a shelter equipped HMMWV with a trailer mounted power generator. The heavy configuration is contained in twenty foot International Standards Organization (ISO) trailers. This unit provides an essentially "brick and mortar" facility capable of confirmatory identification of chemical and biological agents; it is designed for more long term employment scenarios.

Additional Ad Hoc Capabilities

The Department of the Army has additional resources, not specifically programmed for a civil support mission, but available to respond to a domestic terrorist attack. These include Chemical companies stationed on virtually all CONUS U.S. Army posts as well as Reserve and National Guard units throughout the United States. The DA also has a number of assets specifically trained and resourced to deal with bioterrorism. These include the laboratories associated with the U.S. Army Medical Research Institute of Infectious Disease (USAMRIID), the 1st and 9th Area Medical Laboratories. The U.S. Army Medical Command has specially trained Special Medical Augmentation Response Teams (SMART) that are equipped with sophisticated telecommunication equipment capable of establishing communications in virtually any environment. These units can provide limited support to local authorities in the event of a bioterror attack.

Conclusions

The prospect of bioterrorism in the United States is horrifying. Contributing to the anxiety of the bioterrorism threat is the fact that,

aside from the relatively small scale anthrax attack in 2001, there is no experience on which to plan a coordinated response to this specific threat. In the event of a successful attack there may be thousands, if not tens of thousands of victims and, especially in the case of an infectious agent, the number of walking-well patients seeking medical attention will be enormous. Medical treatment facilities will undoubtedly be overwhelmed and a panic stricken populace will attempt to vacate the area. The DA assets programmed for response to this scenario are manifold and, in terms of numbers, probably adequate. A recent evaluation by the Government Accounting Office indicated that, overall, the DOD was far ahead of other federal agencies in planning for a domestic CBRNE event.[13]

But certain shortcomings, particularly with respect to the training, equipping and operational control of the CCMRFs, were pointed out. For example it was noted that identification of training and equipment requirements for the CCMRFs is handicapped by a lack of planning by state, local and other federal agencies under the Integrated Planning System (a program established in 2009 by the Department of Homeland Security to standardize national homeland security planning in response to Presidential Homeland Security Directive 8). This shortcoming has resulted in uncertainty of the gaps the DOD may be required to fill. For example, a National Guard State mission of responding to a catastrophic / natural disaster event. If the 2nd and 3rd CCMRFs were activated and deployed under Title 10 authority and a major natural disaster occurred, a governor maybe required to request assistance from surrounding states for Title 32 support. There is potential for delays in support or specific type of support at state and local levels.

Although there is substantial overlap in capabilities between the resources found in the CST, CERFP, CCMRF progression and the 20th Support Command. It should be recognized that the Title 32 CST and CERFP along with the Title 10 CCMRFs have a mission specifically to respond to a domestic terrorist attack; whereas the 20th Support Command is, in essence, designed to support overseas operations. Nevertheless, the CARA's, RRTs and MALs are tasked and trained to augment DA involvement in support of civil operations. The organization of these units, their mission and their training requirements are currently in a state of flux. The field manual for the CBRNE Headquarters operations is, in fact, designated as FMI 3-90.10, FMI meaning Field Manual Interim to reflect the dynamic nature of current doctrine for civil support operations. How well these DA assets will perform, in the event of a domestic bioterrorism attack, is yet to be challenged by a major incident.

Author's Note. *At time of publishing, the DOD was reviewing CBRNE Force Package tactics techniques and procedures in order to develop more responsive capabilities.*

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Japan Had an Atomic Bomb (Genzai Bakuden) Program in WWII?

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Most of us in the combating weapons of mass destruction (CWMD) community know the history of the United States (U.S.) Manhattan Project and why it was funded. However, few of us knew that Japan had its own "Manhattan Project". Even General Leslie R. Groves, the chief of the U.S. Manhattan Project, had little to say about the Japanese effort in his memoirs. Fortunately, information on their program was eventually documented in Science magazine in 1978. [1 2] In addition, a documentary that aired on the History Channel on 16 August 2005 described the location of a Japanese heavy water facility and a purported atomic weapons test facility in what is now North Korea.[3] While there is no conclusive proof Japan ever developed a fission device or weapon, there is substantial evidence they had conducted their own research program to develop one.

This article is a summary of findings from these and several other sources.[4-13] Most of the findings challenge the ideas that Japan and its military was innocent of involvement in atomic weapon development and that the U.S. atomic bombing of Hiroshima and Nagasaki was unwarranted.

Pre-World War II Interest

Japanese physicists, like most physicists throughout the world, followed closely both the theoretical and experimental nuclear fission research that began in Europe and the experimental work later carried on in the U.S. The work on atomic physics and quantum physics at the Niels Bohr Institute in Copenhagen, Denmark, the pioneering work by Werner Heisenberg and other German physicists on nuclear fission, and the cyclotron development by E. O. Lawrence (University of California at Berkeley) (Figure 1) were of special interest to Yoshio Nishina (co-author of the Klein-Nishina formula) and Ryokichi Sagane of the University of Tokyo. These two world class Japanese physicists would become the leaders of the Japanese nuclear fission research program.

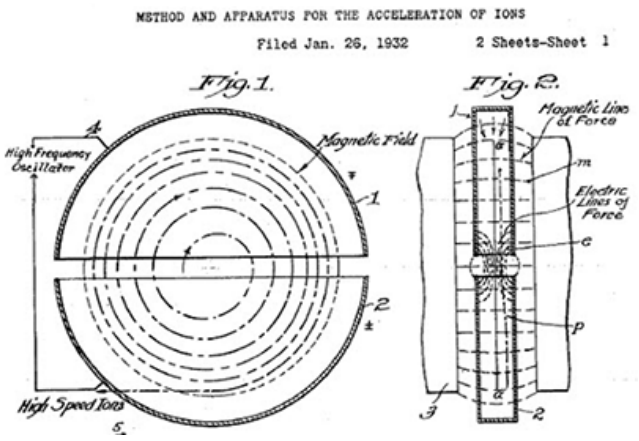


Figure 1. E. O. Lawrence Original Patent Drawing for the Cyclotron [Wikipedia]

Chronology of World War II Activities

1. September 1940 – Japanese scientists (including Nishina and Sagane) proposed atomic bomb research to the Japanese government. The Japanese name for atomic bomb is gensai bakuden.

2. 27 September 1940 – Japan, Germany, and Italy signed the Tripartite Pact (also known as the Three-Power Pact, the Three-way Pact, the Axis Pact, and the Tripartite Treaty). It established the Axis Powers of World War II and was intended to keep the U.S. out of the war. Nine other nations also signed. In time, the Pact was apparently used to exchange information on military research, including the military applications of nuclear fission.

3. December 1940 – Japanese Army-sponsored atomic bomb research began at The Institute of Physical and Chemical Research (Riken) (Nishina's institute in Tokyo). Funding was modest.

4. 1940 – 1943 - A period of growing military interest in developing a Japanese atomic weapon

5. 1941 – Hideki Tojo, who was both Prime Minister and War Minister, ordered an investigation into the possibility of making an atomic weapon.

6. Late 1942 – The Japanese Navy (Naval Institute of Technology) funded some fission research at Riken.

7. December 1942 – March 1943 - The Army set up an experimental project (the Ni-Go Project) at Riken with an additional 700,000 yen ($175,000) to separate the isotope uranium-235 (U-235) via thermal diffusion. In 1943, the Navy Bureau of Ships upgraded their nuclear research program (the F-Go Project) at Kyoto University with 300,000 yen ($70,000). The project was led by Bunsabe Arakatsu. It led to the design and construction of a cyclotron at Kyoto University and the production of 20 grams of heavy water from electrolytic ammonia plants in North Korea and Kyushu (Japan). [11]

8. March 1943 – The Japanese "Physics Colloquium", a series of ten sessions, concluded a fission weapon was too difficult to complete within ten years.

9. April 1945 – As the gaseous thermal diffusion apparatus and the cyclotron began work-

ing together in an experimental mode, the building housing the diffusion apparatus was destroyed in a US B-29 bombing raid over Tokyo.

10. 7 May 1945 – Victory in Europe (V-E) Day. Germany surrendered. Commander-in-Chief of the German Navy Admiral Karl Donitz and the last President of the Third Reich (with the death of Adolph Hitler on 30 April 1945) notified all naval ships to surrender to the Allies.

11. 14 May 1945 – The German submarine U-234 (no apparent reference to uranium-234) surrendered to U.S. submarine Sutton south of the Grand Banks. It was subsequently taken to Portsmouth, NH. (Figure 2) Two of the twelve passengers were Japanese military officers. They committed suicide rather than surrender to U.S. forces and were buried at sea. The high-tech cargo being taken to Japan included technical drawings, examples of the newest electric torpedoes, one crated Messerschmitt Me 262 jet aircraft, a Henschel Hs 293 glide bomb, and 560 kilograms of uranium oxide destined for Japan's own atomic research program. The oxide contained about 3.5 kilograms of the isotope U-235,[11]

Figure 2. U-234 Surrenders 14 May 1945 to USS Sutton and Sunk 20 Nov 1947

12. 26 July 1945 – The U.S. and its Allies issued the Potsdam Declaration. It called for the immediate and unconditional surrender of Japan. Japan refused.

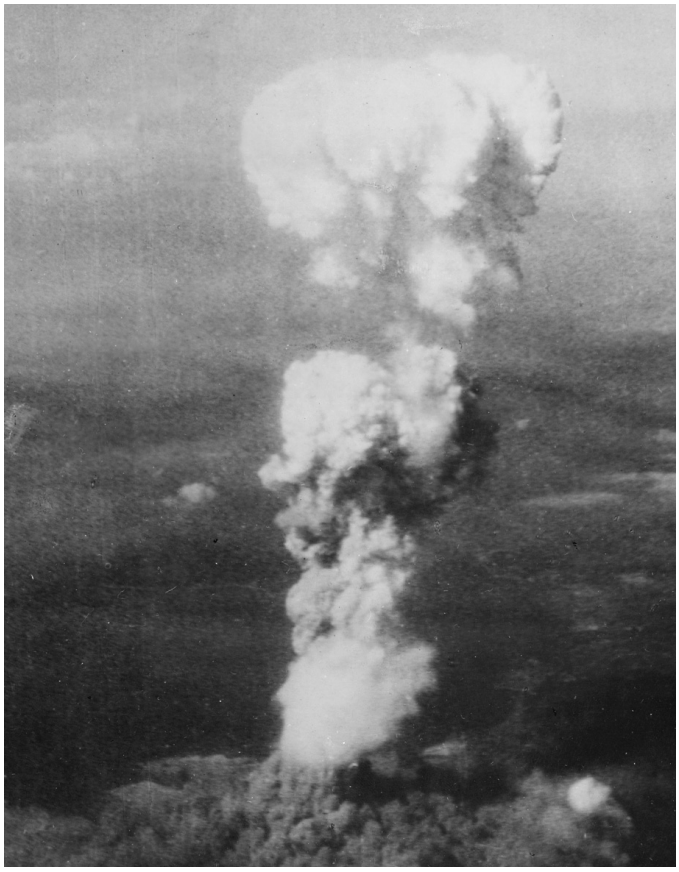


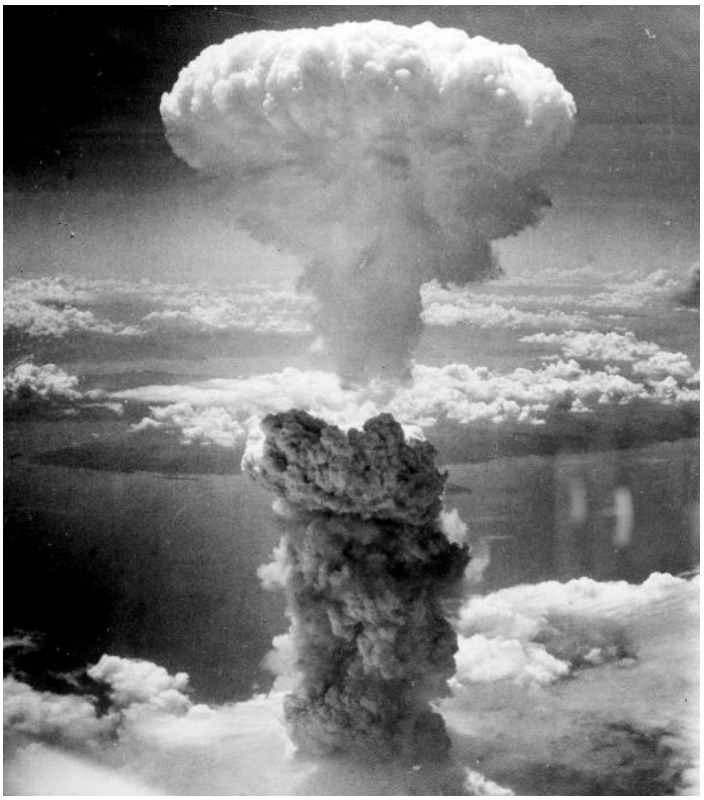
Figure 3. Hiroshima Detonation 6 Aug 1945 (top) and Little Boy

13. 6 August 1945 – The U.S. dropped an atomic bomb on Hiroshima, Japan (B-29 named Enola Gay, Colonel Paul Tibbets commanding). It was a gun-assembly

type weapon using U-235 (codename Little Boy). (Figure 3).

14. 8 August 1945 – Russia declared war on Japan. They quickly occupied Manchuria and then North Korea, capturing many Japanese plants, factories and test facilities.

15. 9 August 1945 – The U.S. dropped an atomic bomb on Nagasaki, Japan (B-29 named Bockscar, Major Charles Sweeney commanding). It was an implosion-assembly type weapon using plutonium-239 (codename Fat Man) A third detonation was proposed by MG Leslie Groves to General of the Army George C. Marshall but never approved by President Harry Truman. It would have been available for use on 17 or 18 August, but the fighting had ended by that time. Three additional weapons would have been available in September and three more in October had they been needed.



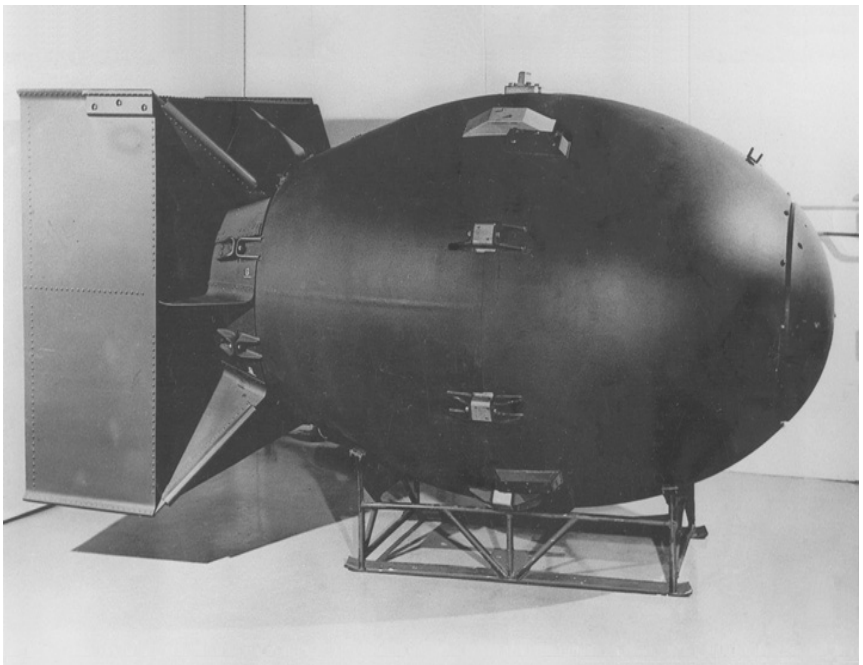


Figure 4. Nagasaki Detonation 9 Aug 1945 (top) and Fat Man

16. Post-Hiroshima detonation - Japan's atomic weapon research program quickly disintegrated. Nishina flew over Hiroshima on 8 August to assess the damage and what caused it. Both he and Arakatsu (who flew over Hiroshima on 10 August) independently concluded the destruction was caused by an atomic bomb. A recorded message by Emperor Hirohito on Domei radio on 15 August 1945 (14 August 1945 U.S. time) announced the acceptance of the surrender conditions of the Potsdam Declaration. The Instrument of Surrender papers were then signed on the U.S. battleship Missouri in Tokyo Bay on 2 September 1945 (known as Victory in Japan (V-J) Day). (Figure 5)

17. 30 October 1945 – The U.S. Joint Chiefs of Staff ordered that all Japanese research facilities and equipment "…on atomic energy and related subjects be seized." "No research…on atomic energy shall be permitted in Japan." [Further Reading 2]

18. 24-26 November 1945 – General Groves ordered that all five of Japan's cyclotrons be destroyed. They are subsequently hacked to pieces and dumped into the sea.

Conclusions

The relatively small-scale Japanese effort to develop an atomic bomb was probably destined to fail. They started quite late, had limited natural resources (e.g., uranium) to support the research, and had no national priority comparable to the U.S. Manhattan Project. And while the rumor of a Japanese weapon test conducted on a small island 20 miles off the coast near Konan, North Korea three days before being captured by the Russians has never been confirmed [Further Reading 3], much information on the Japanese basic fission research program has. We now know that Japan entered into the Tripartite Pact with Germany and Italy (1940) to learn more about German research programs, including nuclear fission, no doubt to supplement their own modest research

programs. That Pact, plus the unreported (until 1978) fact that most of the fission research was funded by the Japanese military to develop a genzai bakuden means the general public was initially uninformed of Japanese efforts to build one. Perhaps the most incriminating evidence of the extent of the Germany-Japan cooperative fission research program was the discovery of uranium oxide on the German submarine U-234 that surrendered to the U.S. before delivering its cargo to Japan.

Evidence now shows the U.S. was not only in competition with Germany to build an atomic bomb; they were in competition with Japan as well. Though the Japanese program probably never went beyond nuclear fission research, the portrayal of Japan as innocent and blameless and the U.S. atomic bombing of Hiroshima and Nagasaki as overkill remains controversial. Nishina and Arakatsu were internationally recognized physicists that had intimate knowledge of atomic bomb technology and its potential damage mechanisms (blast, thermal, and radiation). Both flew over Hiroshima within days after the bombing to survey the damage and report their findings to the Japanese government. They independently concluded the destruction was caused by a U.S. atomic bomb. It is no coincidence Emperor Hirohito formally agreed to the Potsdam Declaration just six days after the Hiroshima bombing. This unconditional surrender clearly stopped the carnage that would have followed an Allied invasion (Operation Downfall) of the Japanese homeland.

Figure 5. Japan Surrenders on US Battleship Missouri 2 September 1945

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9. www.39th.org/39th/hc/hc_japan_a_bomb.html is another website that discusses the test site in North Korea.

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11. Wilcox, R.K., Japan's Secret War, William Morrow and Company, NY, 1985.

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13.http://www.jstor.org/stable/3655253?seq=6 is an article entitled Wartime Nuclear Weapons Research in Germany and Japan that provides additional details not covered in the other articles.

14. Images retrieved from Wikipedia 1,2,3,4 and Wikicommon 5.

Decon Emitting Neutralizer of Improvised Explosive Devices (DENIED)

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Terror attacks using chemical or biological agents pose a grave danger to society. Chemical and biological agents can effectively harm large population centers and cripple the country's perception of its security. National security depends on the government's ability to mitigate emerging threats, so the Department of Homeland Security has taken steps to mitigate these attacks by conducting training exercises for hospitals and first responders.[1] The intelligence community is continuously gathering information on terrorist activities, with chemical and biological plots being among the top priorities.[2] However, there is a gap in technology for first responders. There is no real solution to the "ticking time-bomb" scenario. In other words, what happens if our first responders find such a device in a heavily populated area? How can they render the device ineffective and how can the chemical or biological agents be neutralized?

A recently developed concept, Decon Emitting Neutralizer of Improvised Explosive Devices (DENIED), is an attempt to solve these problems simultaneously. DENIED uses a decontamination solution developed at Sandia National Labs (SNL), to neutralize a wide range of chemical and biological agents. For chemical agents, the solution bonds with the chemical's central atom and breaks the agent into two smaller, harmless molecules; for biological agents, the surfactants poke holes in the spore's membranes, allowing the oxidizing agent to destroy the genetic material. The SNL solution has already been tested in the lab and the field against an array of agents.[3] The DENIED system delivers this solution to a weaponized agent by using a shaped charge loaded with sheet explosive. The shaped charge is in the form of an arc that projects the solution as a blade, allowing it to penetrate the suspected weapon.

Theory

The first prototype of the DENIED project is the Rivers' Box (RIVBOX). Using the SNL solution allows the decontamination of the agent to start as soon as the blade penetrates the target. While the blade of decontamination solution disrupts the target, it also mixes with the payload. The solution must mix with the payload so it can microscopically destroy the agents.

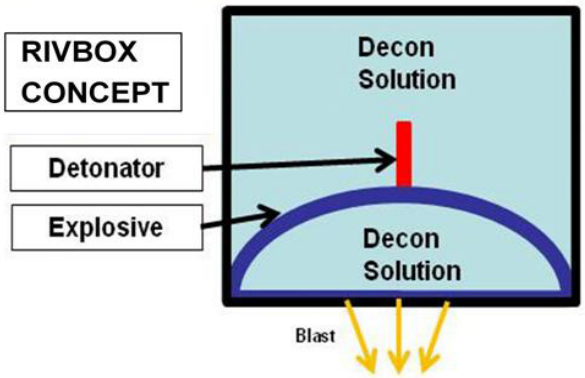


Figure 1. Depiction of the RIVBOX Concept.

Hence, the solution that physically destroys the triggering mechanism also decontaminates the agent. The first prototype concept is the RIVBOX as seen in Figure 1:

The idea of using fluids to disrupt devices is fairly common on the modern battlefield. Explosive ordnance disposal (EOD) units have an array of directed liquid penetrators for precision destruction of improvised explosive devices.[4] EOD units from all services have been using explosively propelled water to defeat improvised explosive devices in Iraq and Afghanistan.

The RIVBOX is unique because it aims to combine the effectiveness of an explosively driven liquid penetrator with the neutralizing capability of a decontamination solution. This combination is made possible with the use of a heat shield between the explosives and the solution. This protects the solution from the high temperatures of the detonation. The heat shield is the thin layer of plastic or metal that supports the explosives in the shape of an arc, and it prevents excessive heat from degrading the decontamination solution before leaving the device. Since the solution is being driven by an arc, it takes the shape of a blade, which offers the best balance

between penetration power and spread of solution. Furthermore, the solution is effective against a wide range of agents, especially in a situation where identifying the agent may not be possible in a timely manner.

Experiment

Phase One Concept Test. The purpose of this test was to determine the penetration and delivery capabilities of the RIVBOX. In the desired end state, the RIVBOX would penetrate the intended target and effectively spread the decontamination solution throughout the target's interior. Using the trunk of a compact car as the target, a high speed camera captured the detonation of the device at 7,000 frames per second.

Figure 2. The RIVBOX on Top of a Vehicle Trunk and a Picture of the Contents of the Trunk before the Test.

This test was very successful. The solution moistened the interior of a prepositioned crate within the trunk. Signs of moisture could be detected all the way through the trunk to the ground. The solution also coated objects within the trunk and the trunk itself. The physical destruction and coating of the target positively confirm the RIVBOX's capabilities and provide proof of principle for the next phase of testing.

Phase Two Concept Test. Phase one testing assumed that the decontamination solution did not change after exposure to the high pressures and temperatures of an explosion. Additionally, phase one testing assumed that this technology relies on a professionally produced RIVBOX. Phase two addresses both of these assumptions: Does exposure to high pressure and temperature degrade the

Figure 3. Picture of the RIVBOX Exploding and the Contents of the Trunk after the Explosion.

effectiveness of the decontamination solution? How great is the difference in results when comparing a commercial off-the-shelf (COTS) product to a field expedient device?

Previous work at SNL measured effectiveness using simulant testing, by annotating the amount of simulant destroyed. However, in explosive outdoor testing, simulants add various complications due to their mild toxicity levels. Simulant testing also requires spectroscopy or some means of precise measurement. Explosive testing results in a solution with explosive residue, target residue, and uncontrolled atmospheric variables. Therefore, phase two employed a metric for effectiveness that minimized these variables. In order to determine if the chemical composition changes during the RIVBOX detonation, chemical concentration acted as a measure of effectiveness. Hydrogen peroxide is the most volatile part of the solution and as an oxidizing agent, plays a vital role in effectiveness. Therefore, it was assumed that the hydrogen peroxide concentration correlates to the solution's effectiveness.

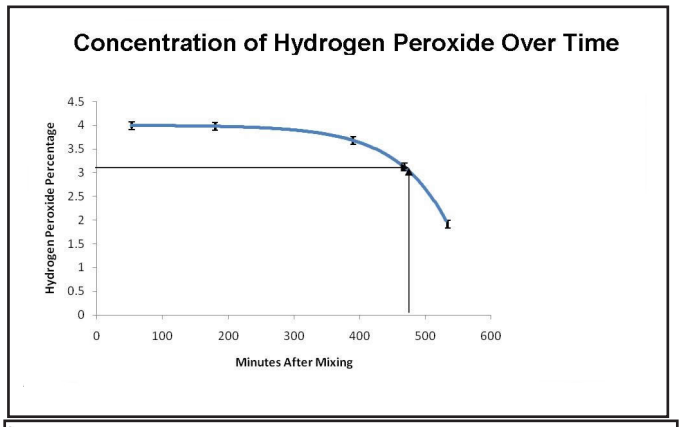
The manufacturer of the solution, Modec, Inc., claims that the solution is effective for a period of eight hours after mixing. The concentration of hydrogen peroxide was measured as a function of time, using a hydrogen peroxide assay kit from Cayman Chemical Co. (Catalog No.

706011) which was originally made for measuring natural concentrations of hydrogen peroxide in human urine. The ratio of hydrogen peroxide in human urine to the amount in the decontamination solution is about 1:10,000. Therefore, the solution was diluted to 1:10,000 for the measurements.

Samples of the solution were mixed at hourly time intervals for nine hours. The kit works by using iron ions that react with the hydrogen peroxide and a reagent to produce a dye that is 595 nm in color. Then, a plate reader shined 595 nm light into each sample and measured the amount of light absorbed. The results indicated that the solution started losing hydrogen peroxide when all three parts were mixed.

The same process was used for samples with known concentrations of hydrogen peroxide. The relationship between light absorbance and known concentrations allows for the unknown concentrations of the decontamination solution to be calculated as a function of time. Each data point had four trials that added to the accuracy, though only averages were used in the actual calculations. Figure 4. shows the results along with the 480 minute (8 hour) mark where the solution is no longer effective.

The manufacturer claims that the solution starts with 4.0% hydrogen peroxide, which our data supports. The results also show that at the 480 minute (8 hour) mark the concentration of hydrogen peroxide is 3.1%, which accomplishes the goal of this explosive testing – to determine if the concentration of hydrogen peroxide lost during the explosion is greater than 0.9%.



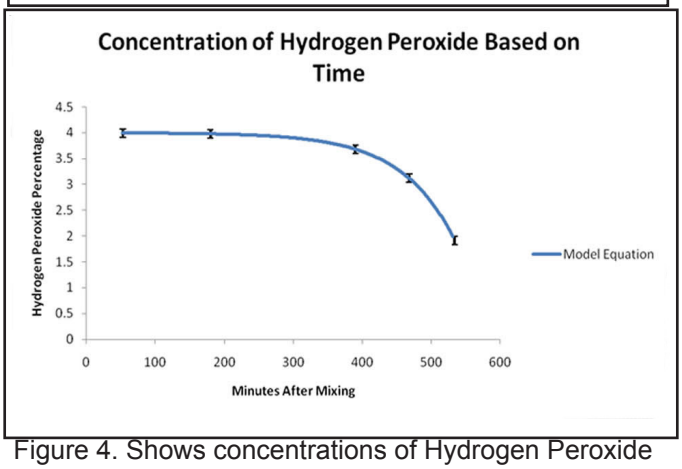


Figure 4. Shows concentrations of Hydrogen Peroxide over time.

Phase two also sought to test different designs of the RIVBOX concept. In the end, the professionally developed RIVBOX effectively disrupted one test target, while three different field expedient versions also disrupted targets successfully.

Each RIVBOX shared the same overall design, but the field expedient RIVBOX was far less expensive. The components of the field expedient RIVBOX are M118 sheet explosive, a plastic container, and aluminum foil tins. The physical results yielded similar disruption of the test targets among all the prototypes. These results suggest that the exact shape, material, and construction are not critical for physical penetration. Additionally, as in the previous test, the solution covered the entire interior of the test targets.

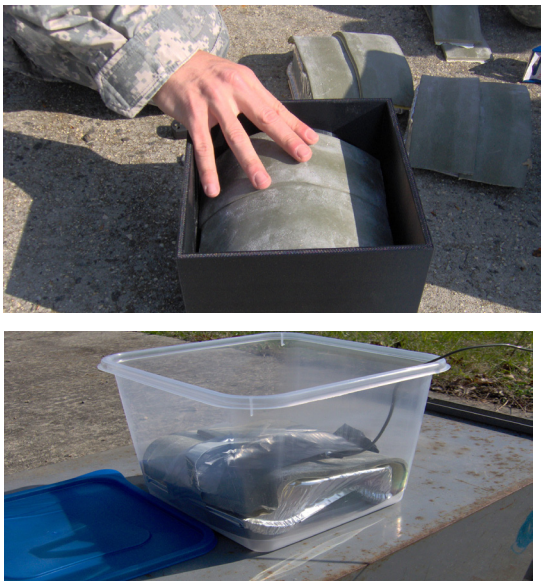


Figure 5. Shows the Professional RIVBOX and the Field Expedient RIVBOX.

To measure the change in hydrogen peroxide concentration, samples of solution were taken before and after the explosion and were placed into a chilled

Figure 6. Shows the Disruption of the Steel Cabinets.

container in order to minimize the amount of hydrogen peroxide lost while cleaning and clearing the testing area. Again, each sample was an average of 4 trials, and the same dilution, as the first chemical test, was used. The chemical testing began 3.5 hours after the explosive trials were completed. According to the results, the professionally manufactured RIVBOX yielded a 0.1% decrease in hydrogen peroxide, while the field expedient RIVBOX yielded a 0.2% decrease in hydrogen peroxide. These results fall within the 0.9% effective window.

Conclusions

The RIVBOX testing was divided into two phases. The first phase of testing was used to determine if the RIVBOX could physically penetrate a potential target while coating the target's interior with a decontamination solution. The first explosive test exceeded expectations – it used minimal explosives to project a blade of decontamination solution all the way through the trunk of a car, and coated the interior of the trunk with solution. Follow-on tests with steel cabinets produced similar results. The RIVBOX successfully disrupted the targets and applied a layer of solution.

The second phase of testing was used to ensure the integrity of the chemical composition under the high temperatures and pressures of the detonation. The result of the concentration testing shows a 0.9% window of effectiveness, and the explosive testing shows a hydrogen peroxide concentration loss between 0.1%-0.2%. Each test was within the 0.9% window. These are just initial results. The RIVBOX requires additional testing at more advanced facilities that can model the mixture of the solution with potential agents and produce a more thorough report of chemical effectiveness. The decontamination solution to explosives ratio needs to be optimized to ensure proper mixing and concentration in order to neutralize the payload. Optimization should be a part of the next phase of development and testing.

The combination of both phases shows that DENIED is a concept worth pursuing. Further testing should include mixing the decontamination solution with chemical and biological agents inside the device to ensure effective neutralization. However, the RIVBOX shows great promise as a low-cost tool against improvised chemical or biological devices.

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ENDNOTES

i United States Military Academy Department of Physics and Nuclear Engineering

ii United States Military Academy Department of Chemistry

iii US Army Explosives Ordnance Disposal Technology Directorate

1. Author participated in these drills in his work as an Emergency Medical Technician in CT 2004.

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4. Discovery Channel, Future Weapons: Bootbanger: http://dsc.discovery.com/videos/future-weapons-bootbanger.html.

The Spore Casing as Defense for the "Anthrax" Biological Agent

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The "Anthrax" Spore Threat

Anthrax is a disease of humans and warm-blooded animals caused by a bacterium named *Bacillus anthracis*, a microbe identified in 1875 by the pioneer microbiologist Robert Koch. The bacterium can be isolated from soils of many areas throughout the world, including agricultural regions of central North America from Texas to Canada (Pepper *et al.,* 2002; Dragon *et al.,* 2005). Consequently, anthrax occurs in many countries among wild and domesticated herbivorous mammals as a result of the bacterium being ingested or inhaled during grazing. Anthrax also occurs among humans in many countries (World Health Organization, 2008). Human anthrax typically results from unprotected handling of infected animal carcasses or products (hides and wool) or consumption of improperly prepared food of diseased animals. While about 20,000 to 100,000 cases of human anthrax occur annually worldwide, mostly in developing countries, human anthrax in the U. S. is very rare. The disease is controlled in the U. S. by an effective vaccine, given to veterinarians and personnel of livestock industries, and inspection of animals before and after slaughter for food.

While human anthrax in the U. S. is rare, notable cases of the disease have been reported. In 2007 a Danbury, Connecticut, drum maker and one of his children contracted anthrax through exposure attributed to contaminated goat hides imported from Guinea in West Africa (Centers for Disease Control and Prevention, 2008). An environmental investigation conducted by the FBI, EPA, and Connecticut Department of Environmental Protection revealed contamination of the drum maker's work shed and residence which required extensive fumigation with a disinfectant (chlorine dioxide) to render the dwellings safe for occupation. The disease manifested as a skin lesion, with the infection likely resulting from the organism contacting broken skin. Fortunately both individuals were successfully treated with appropriate antibiotics.

Rather than occurring by natural causes as was the case with the Danbury incident, human anthrax can be the consequence of exposure from deliberate acts of war or terrorism. Utility of *Bacillus anthracis* as a biological weapon may have originated as early as the 1930s, when, as reported, the Japanese Kwantung Army Unit 731 intentionally exposed the bacterium to thousands of war prisoners in Manchuria (Eitzen *et al.,*1997). During the past decade, *Bacillus anthracis* has emerged as a formidable biological threat to the U. S. military and homeland. The warfighter is aware of the biological agent's potential impact on the battlefield. As defense for such an attack, warfighters have been vaccinated for protection against the agent. Knowledge of the organism's potential also extends to U. S. civilians. From news broadcasts that abounded about ten years ago, the public learned numerous details on the havoc that *Bacillus anthracis* presented as an agent packaged as a dry powder in letters delivered to unsuspecting individuals. Among various microorganisms regarded as biological threats to the battlefield or homeland, *Bacillus anthracis* often predominates as an agent of concern due to unique properties associated with the microbe existing in the form of a spore. As one of a variety of microbial forms, the spore can exist in a dormant "sleeping" state and remain viable for extended periods under harsh conditions. In addition, spores typically are tolerant to disinfectants and other antimicrobial compounds that easily kill other microbial forms. This tolerance requires elevated disinfectant concentrations or longer exposure times to adequately kill spores. The key to the spore's tolerance or hardiness is the organism's multi-layered casing that surrounds and protects the organism's interior. Like a fortress that wards off invading enemies with a moat and steep walls, the spore casing can protect the organism in adverse conditions. Consisting of a series of concentric layers, the structure includes a barrier layer that can protect the spore by limiting entrance of antagonistic materials when the spore finds itself in a hostile environment. Another layer provides structural strength to the spore. In addition, some components of the casing are able to tolerate reactive compounds, such as disinfectants, and maintain their protective function. This article presents *Bacillus anthracis* as

a spore, describing how the spore's casing contributes to the microbe's nature as a formidable biological threat and challenge to biological defense.

The *Bacillus anthracis* Spore: A Unique Microbe

Microorganisms are ubiquitous and have been found in essentially every type of environment around the world, including harsh regions that are inhospitable to almost all life forms (Finlay *et al.,* 2001). Microbes have been isolated from areas of extreme temperatures, including soils of Antarctica and waters of ocean hydrothermal vents where temperatures were reported to reach -128.6°F and 867°F, respectively. Inhospitable regions that are laden with metals, salts, or other toxic compounds have been found to be colonized by a great variety of microbial species able to tolerate the noxious materials. To comprehend the possibility of microbial life on Mars, NASA scientists have studied microbial populations of soils collected from Antarctica and the Atacama Desert in South America as the coldest and driest regions, respectively, on Earth. Scientists have also postulated that microbes could survive in outer space (Horneck *et al*., 2010).

The many microorganisms that have been isolated from diverse environments and identified by scientists as microbial entities can been classified into basic taxonomic groups, which include bacteria, viruses, fungi, algae, and protozoa. Fortunately, only a small number of the many microbial entities are human pathogens (organisms capable of causing human disease). As another positive fact, most human pathogens, upon shedding from an infected human host into the environment, do not thrive and eventually die during exposure in air, on surfaces, or in water. In addition, human pathogens usually are sensitive to and effectively killed by disinfectants. However, *Bacillus anthracis*, as the causative agent of anthrax, is an exception since it can exist in the form of a spore. As a spore in a dormant state, *Bacillus anthracis* can endure austere environments for extended periods. Survival of the *Bacillus anthracis* spore is exemplified by the reported persistence of the pathogen on Gruinard Island, a remote uninhabited region off the coast of Scotland (Manchee *et al.,* 1994). In 1942 Porton Down scientists detonated bombs of *Bacillus anthracis* on the island and monitored the health of sheep as susceptible hosts to ascertain the feasibility of an "anthrax attack" by the Germans. As a testament to spore durability, the pathogen survived on the island for many years until extensive decontamination treatment was conducted in 1986. Treatment involved spraying 280 tons of formaldehyde diluted in seawater over about 485 acres of land. Warning signs were finally removed from the island in 1990, 48 years after the pathogen's release.

It is not surprising that *Bacillus anthracis* persisted in Gruinard Island soils since spore-forming microbes thrive very well as predominant microbial entities of soils. Soils are typically laden with various bacteria and fungi that are able to exist as spores. The possibility of extreme longevity of spores in ground environments is suggested by a scientific report on the isolation of a spore-forming bacterium from the interior of an ancient salt crystal buried about 2,000 feet below the desert floor of Carlsbad, New Mexico (Vreeland *et al.,* 2000). Based on the age of the crystal, the scientists claimed the spore, that was named "Bacillus strain 2-9-3," may have existed within the crystal for 250 million years.

Spore-related properties of *Bacillus anthracis* contribute to the pathogen's potential use as a formidable biological agent. Tolerance to harsh environments could allow the organism to survive and remain infectious during release and dissemination at target attack sites. In addition, released spores could persist and remain infectious for extended periods at attack sites and consequently increase the number of exposed persons and exposure time. The potential power of the *Bacillus anthracis* spore as a threat is broadened by the ability of the pathogen to cause disease by any of three exposure routes, those being inhalation, ingestion, and dermal contact. By comparison, most human pathogens are capable of causing disease by only one or two exposure routes. Multiple exposure routes combined with spore hardiness broadens the scope of possible attack scenarios. Potential means of exposure include introducing aerosols (air containing spores as particles) to enclosed or open air spaces as well as deliberate contamination of food and water supplies. Fortunately, anthrax is not transmitted by human-to-human contact as is possible with other pathogens such as those that cause influenza or plague.

While *Bacillus anthracis* has the potential to cause illness (morbidity) that can lead to death (mortality), medical countermeasures are available for effective protection or treatment. During vaccination with a series of shots, an individual develops immunity that provides protection against exposure to the pathogen. For those not protected by vaccination, antibiotics such as ciprofloxacin or doxycycline are effective if administered soon after exposure or at early stages of the disease. While an anthrax incident can be abated or controlled with medical countermeasures, an extensive biological attack could create a serious situation that requires decontamination of large areas or complex materials. Decontamination of *Bacillus anthracis* could be a great challenge due to the innate tolerance of spores to disinfectants such as "chlorine bleach" (Calomiris, 2004) and chlorine dioxide (Chatuev *et al.,* 2010). This is exemplified by the 2001 "anthrax letter" attacks and the extensive effort (hundreds of millions of dol-

lars cost for over two years) required to reduce *Bacillus anthracis* spore numbers of contaminated buildings to acceptable levels (Franco *et al.,* 2010). Understanding the properties of *Bacillus anthracis* as a spore could provide the basis for developing more effective means to control the biological agent. The significance of the spore casing as the organism's protective armor and a challenge to biological defense is discussed in this article.

A Tale of Two Forms: *Bacillus anthracis* as Spore or Cell

As presented in the above section, *B. anthracis* as a dormant spore is a "sleeping" entity that can survive austere environments, tolerate disinfectants, and cause human disease. However, as other microbes that exist as a spore, the life cycle of B. anthracis has a dual nature due to the microbe's ability to exist as either a spore or a cell. Should a spore find itself in a nutrient-rich environment (such as an animal host or laboratory beef broth), the resting entity can awaken and transform into an active cell form through the process of germination. As a cell in a lush environment, the organism is metabolically active, feeding on nutrients, growing, and dividing into new cells. However, unlike the spore, the cell does not survive well in harsh environments, is sensitive to disinfectants, and is not infectious. To continue the life cycle, an active cell that encounters harsh or nutrient-poor conditions can produce a spore through the process of sporulation. This spore-to-cell dual nature provides the organism flexibility, allowing the dormant spore to survive an inhospitable environment or enabling the cell to multiply and increase the number of organisms under favorable conditions.

A major difference between the spore and cell that greatly impacts the bacterium's nature is the casing of the organism. All bacteria, as the spore or cell form, are bounded by a shell structure that houses the organism's components, including a nucleoid that organizes DNA as genetic material, ribosomes as structures involved with synthesis of proteins, enzymes that catalyze numerous reactions, and granules that house nutrient reserves, lipids, and inorganic compounds. In addition, the casing serves as a protective barrier for the bacterium. Having direct, intimate contact with the organism's environment, the casing provides the first line of defense by excluding or limiting the entrance of environmental materials that could harm the organism. While functioning as a protective barrier, the outer structure also allows entrance of essential nutrients and other materials needed by the bacterium to survive and grow.

Compared with the casing of the spore, the casing of the bacterial cell is more interactive with the organism's environment. This interaction is directed by two pathways designed, under ideal conditions, to allow entrance of nutrients into the organism while excluding materials that could harm the organism. The lipophilic pathway, as a lipid membrane structure that encases the entire cell like a balloon, imparts a hydrophobic surface and, thus, tends to repel water. The lipophilic pathway can allow passage of hydrophobic (water insoluble) compounds into the cell while excluding hydrophilic (water soluble) compounds. The hydrophilic pathway, which consists of structural proteins (porins) embedded throughout the cell's lipid membrane, provides water-lined channels as conduits for passage of small hydrophilic compounds into the organism. In a favorable environment, both pathways promote the survival of the bacterium by allowing nutrients to enter the cell while excluding harmful materials. However, the presence of harmful compounds of size or solubility that allows passage through the cell casing could lead to the death of organism. In addition, a variety of compounds (detergents, disinfectants, and organic solvents) can react with cell casing components and thereby destroy the protective structure. Disruption of the barrier can lead to leakage of vital cellular components from the cell and less restricted entrance of harmful environmental materials into the cell. These events usually result in the bacterium's death.

Unlike the casing of the bacterial cell, the casing of the spore is generally less interactive with the organism's environment. This is attributed to the spore surface being much more hydrophobic than the outer region of the bacterial cell (Doyle *et al.,* 1984). As such, spores suspended in aqueous environments could behave like oil droplets in water. Consequently, for spores suspended in a typical water-based environment, the hydrophobic spore surface would tend to repel hydrophilic compounds of the aqueous environment and reduce the association of adverse compounds with the organism. The hydrophobic nature of the spore surface could contribute to spore's basic tolerance to a variety of hydrophilic antimicrobial compounds, such as hypochlorite (the active component of "chlorine bleach"), chlorine dioxide, and hydrogen peroxide.

The *Bacillus anthracis* Spore Wall: A Hard Cookie to Crack!

As discussed in the preceding section, the spore surface with its hydrophobic nature plays a role in limiting the entrance of unwanted environmental materials into the organism. Compared with the casing of the bacterial cell, the spore shell has more layers, with the layers being more complex and thicker. Architecturally, the spore casing, as a series of concentric layers, presents multiple obstacles that can limit the entrance of materials present in the spore's surrounding environment (Figure 1). However, antimicrobial materials, such as disinfectants, have some capacity to enter the spore and exert deleterious effects (Riesenman *et al.,* 2000; Tennen *et al.,* 2000; Young *et al.,* 2003). But the spore's survival during

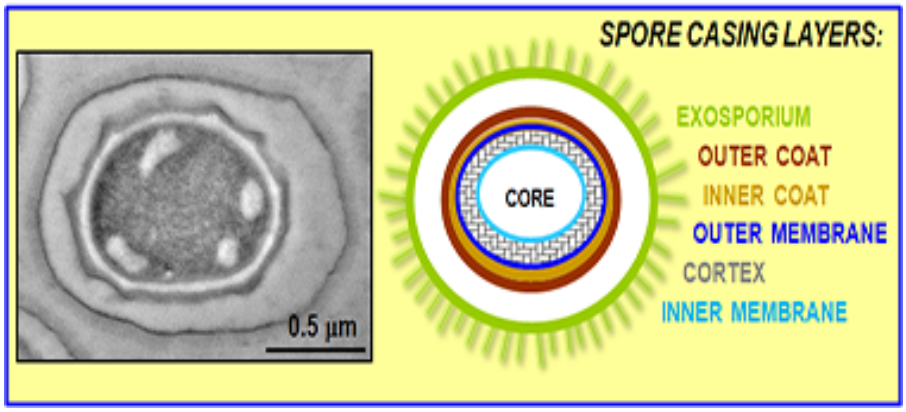

Figure 1. Cross-section of the Bacillus anthracis spore casing architecture. The spore casing consists of a series of concentric layers that surround and protect the core of the organism.

disinfectant exposure is typically a function of disinfectant concentration and time which, as factors of diffusion, influence the quantity of disinfectant molecules that enter the spore. In addition, the spore's fate is influenced by the type and extent of reactions of the disinfectant with the various layers of the casing. Entrance of many disinfectant molecules into the spore and gross alteration of the casing layers resulting from deleterious reactions could lead to the demise of the spore.

The outer most structure, which has direct contact with the *Bacillus anthracis* spore's environment, is the exosporium. As a loose fitting layer, the exosporium does not appear to exert a barrier function since many materials are able to freely traverse the structure. The exosporium is unique since it has only been found to be present in two other spore-forming bacteria (*Bacillus cereus and Bacillus thuringiensis*) which are genetically related to *Bacillus anthracis*. The exosporium structure of *Bacillus anthracis* consists of a base layer with distinctive finger-like projections composed of glycoprotein (a sugar-protein hybrid biomolecule). While researchers have presumed the exosporium may play a role in the ability of the *Bacillus anthracis* spore to infect its host, experiments with laboratory animals failed to demonstrate the requirement of the structure to cause disease (Brahmbhatt et al. 2007). However, the exosporium's hydrophobic nature contributes to the spore's hydrophobic surface and, thus, how the organism interacts with and, perhaps, survives in its environment.

The coat, as the next layer of the casing, plays a major role as a barrier that offers the spore protection against antagonistic compounds (Driks, 1999). As a permeability barrier, the coat prevents passage of many environmental materials into the spore. Behaving like a molecular sieve, the coat only allows passage of smaller compounds, which can include nutrients present in the spore's environment. Compounds with a mass about 50-fold greater than that of a molecule of glucose may be too large to effectively pass through the coat. Composed primarily of proteins, the coat consists of a dense outer region and a less dense inner region. The coat's outer region is strengthened by many sulfur-bond bridges that crosslink amino acids, the building blocks of proteins. Since hypochlorite is reactive with certain amino acids and can break the sulfur bridges, exposure to the disinfectant would be expected to weaken the coat barrier. However, the spore exhibits some tolerance to hypochlorite at lower concentrations, such as those of chlorinated drinking water (Calomiris, 2004). Elevated hypochlorite levels and extended exposure periods could be required for hypochlorite molecules to sufficiently react with amino acids of the coat and enter the spore.

As the next layer of the casing, the cortex is a complex web-like structure composed of crosslinked peptidoglyan (a protein-sugar hybrid biomolecule) (Haridasan *et al.,* 2002). An outer membrane layer may be located between the coat and cortex. The cortex provides structural strength and can maintain its integrity under extreme pressure. However, unlike the protein coat, the cortex is refractory to oxidants such as hypochlorite and requires strong reactions with acids for degradation. Alternately, the cortex can be degraded under mild conditions by an enzyme (lysozyme) that catalyzes a hydrolytic reaction that breaks the peptidoglycan crosslinks. However, spores exposed to lysozyme retain their cortex structure since the lysozyme molecules are too large to pass through the coat barrier and reach the cortex. But spores lacking coats (by treatment with alkali or the enzyme proteinase which digests proteins) are sensitive to lysozyme since the enzyme can reach and digest the cortex.

As the inner-most layer of the casing, the inner membrane surrounds the core, the central region of the spore. The lipid-based membrane as a protective barrier restricts passage of compounds, including those of smaller size, into the spore core. However, unlike the coat or cortex, inner membrane is not refractory to chemical insult. Sensitivity of the inner membrane to various oxidizing compounds (such as hypochlorite, chlorine dioxide, and hydrogen peroxide) was suggested by research findings demonstrating that oxidizing compounds can increase the membrane's permeability (Cortezzo *et al.,* 2004).

Finally, there is the core, the central region of the spore. The core contains the spore's guts needed to produce a cell when environmental conditions trigger germination. Thus, protection of core constituents (DNA, enzymes, and other biomolecules) is crucial to ensure germination is successful for

generating a new cell. Protection of DNA, as genetic material, is afforded by small proteins that bind to the DNA structure and absorb environmental insults that reach the core so that the DNA remains untouched. A very important condition for protection of core constituents and maintenance of the spore's dormant state is the dryness of the core. The significance of the lack of water in the spore core is presented in the next section.

Key to *Bacillus anthracis* Spore Survival: No Water!

As a general premise, water is required to sustain life. Water is essential for survival of the bacterial cell, which utilizes the liquid to maintain its vital activities for metabolizing nutrients, growing, and dividing into new cells. However, for the bacterial spore to maintain its dormancy and survive under austere conditions, water molecules are not welcome in the spore core. In the absence of water, the spore core's various biomolecular machineries used to produce a new cell are locked and, thus, the spore is dormant. Within the confines of the dry dormant core, DNA is sequestered in a crystalline state, enzymes and other biomolecules involved in germination remain inactive, and the spore sleeps.

The spore is designed to restrict water from the organism, particularly from the core. Absence of water in the dormant *Bacillus anthracis* spore core can be observed by phase-contrast microscopy, with the dry core appearing bright due to the difference in the refractive index of the core and water environment (Figure 2). A key component to the spore's anhydrous state is the compound dipicolinic acid (DPA). As a small molecule that complexes with calcium, DPA occupies much of the core space and thereby displaces water or toxic compounds of the spore's environment. The significance of DPA for its potential to keep the core devoid of water is reflected by the compound comprising 20 percent of the core's mass and 10 percent of the mass of the entire spore. While DPA resides within the dormant spore as a drying agent, during germination there is a rapid exodus of DPA from the spore and, as a result, a rapid egress of water molecules into the spore. DPA release is regarded as a characteristic indication of the germination process. In addition, because DPA is unique to the bacterial spore, some technologists believe that DPA can be utilized for strategies to detect *Bacillus anthracis* as a biological agent.

The cortex may also play a role in maintaining the anhydrous state of the spore core. As presented above, the cortex is a web-like layer that provides the *Bacillus anthracis* spore structural strength. Researchers have suggested that the cortex could play a role in maintaining the desiccated state of the spore core (Westphal *et al.,* 2003). Microscopic examination and spore size measurements indicated that the bacterial spore, prepared as a dry powder, can swell in response to increases in relative humidity. It was suggested that humidity-induced spore swelling could be attributed to the cortex web structure expanding and thereby increasing the overall size of the spore. During this expansion process, the cortex could exert force against the inner membrane that surrounds the core, prevent the core from expanding, and thereby limit entrance of water into the core. In addition, the force of the expanding cortex against the coat was postulated to expand the coat by unfolding of the coat's proteins. This proposed process would promote core dryness and, consequently, spore dormancy. Thus, the dormant spore is not completely inert but could respond to environmental changes while remaining dormant. Like a person who walks in his sleep, the dormant spore could contract and expand while asleep.

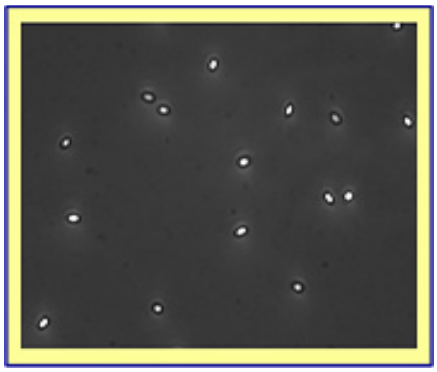

Figure 2. *Bacillus anthracis* spores suspended in water observed by phase-contrast microscopy. The spore (elliptical shape, approximately 1.5-μm long and 0.8-μm wide) displays a bright center due to the refractive index difference between of the dry core and the water environment. The spore casing appears as a dark ring surrounding the core. Image produced by the author.

How does the sleeping *Bacillus anthracis* spore awaken? Germination

Under hospitable environmental conditions, the dormant spore can awaken and produce an active cell. The cell can grow and then divide into two cells, with continued growth and divisions yielding logarithmic production of many cells. The germination process is initiated or triggered if and when the environment provides specific chemical compounds, commonly termed germinants, to the spore (Setlow, 2003). However, for germination to be fully successful in producing a viable cell, the environment must also provide building blocks needed for production of molecular structures, such as proteins, lipids, and genetic material, which constitute the new organism. In addition, an energy source, such as glucose, is required to fuel the synthetic processes that generate a new cell.

Spore germination can occur under a variety of conditions and scenarios. A dormant spore planted in a nutrient-poor soil could germinate in response to a rain event that produces a water conduit that transports germinant compounds from a nutrient-rich region to the spore. While soil-induced germination of spores has been demonstrated for microbes such as *Bacillus cereus* (Vilain *et al.,* 2006), germination of the *Bacillus anthracis* spore in natural environments most likely involves

infecting an animal host (Dragon *et al.,* 1995). However, some researchers have reported germination of *Bacillus anthracis* spores associated with the roots of plants under laboratory conditions (Saile *et al.,* 2006).

Anthrax, as a human or animal disease, requires germination of the spore after it enters the host. The disease process, as for inhalation anthrax, involves spore deposition in the alveoli (small air sacks) of the lungs and ingestion by alveolar macrophages (white blood cells that engulf and digest microbes and other debris). While macrophages can kill many of the spores they ingest, some spores can survive and proceed to cause disease. The macrophages serve as a Trojan horse that transports surviving spores to lymph nodes which provide conditions for germination. Upon germination, cells are able to rapidly grow and increase in number in the bloodstream since the cells are encased in a capsule (a thick outer coating composed of a protein polymer) that protects them from macrophages. The cells produce toxins that destroy tissue, cause bleeding, and lead to the death of the host

Germination of the *Bacillus anthracis* spore can also occur in a laboratory under controlled conditions. As germinants, an amino acid (L-alanine) and another compound (inosine) are commonly employed to trigger germination of *Bacillus anthracis* in a test tube. If conducted with inclusion of growth nutrients, such as a beef broth, the germination process can proceed to production of complete cells that can grow and produce many new cells. A variety of germinants (include various amino acids, sugars, and salts) have been identified by laboratory experimentation. In addition, mechanical abrasion and barometric pressure have been reported to initiate spore germination.

Should a dormant spore have the good fortune of its environment

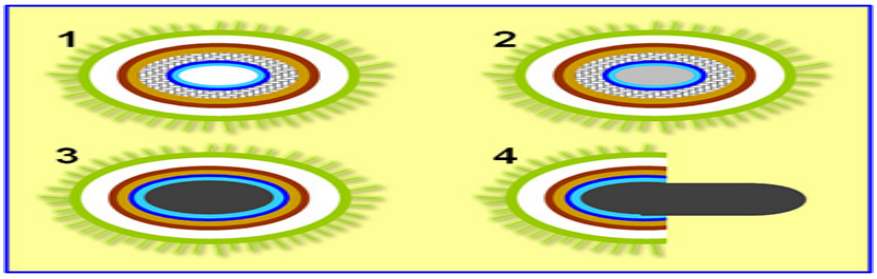

Figure 3. Process of *Bacillus anthracis* spore germination. 1: Dormant Spore (intact casing and dry core). 2: Stage I Germination (release of DPA and calcium from core, core hydration, increased permeability of inner membrane causing spore sensitivity to antimicrobials). 3: Stage II Germination (coat disruption, cortex degradation, additional core hydration and swelling, greater spore sensitivity to antimicrobials). 4: Cell growth (synthesis of cell components and release of cell from degraded spore components).

transforming from bad to good, what mechanisms would allow the lucky organism to awaken and take advantage of its new hospitable habitat? At the molecular level, spore germination is a rapid sequential process initiated within seconds with new cell growth occurring within minutes (Figure 3). Spore activation, as the awakening event of the germination process, typically results from germinants, as specific small chemicals, travelling from the spore's environment, traversing the casing layers, and reaching receptors located around the area of the inner membrane. Receptor binding immediately leads to the opening of channels that direct the exit of the dipicolinic acid depot from the spore core. As water fills the large void in the core left by the dipicolinic acid release, the spore interior assumes a hydrated state which furthers the germination process. With the arrival of water, enzymes in the cortex become active and degrade the cortex structure. In addition, the flux of water activates protein-degrading enzymes associated with the coat, resulting in the disruption of the coat structure. The water also engages enzymes and machinery within the core to produce a new cell. Because the cortex and coat structures have been breached by enzymes, the growing cell is able to push through the spore casing layers and emerge from the spore debris.

While many new multiplying cells can emerge as the result of a dormant spore finding its way to a salubrious environment, the fate of the new cells is not final. Should the environment change for the worse, the cells could die since their outer layers are fragile and not as protective as the spore casing. Alternately, certain adverse conditions can trigger the production of a new spore within a cell through the process of sporulation. The new spore can survive while its mother cell succumbs to the austerity. As such, the cycle of a bacterium, such as *Bacillus anthracis*, continues and the species is able to persist under both favorable and unfavorable conditions.

How does *Bacillus anthracis* transform from an active cell to a sleeping spore? Sporulation

Bacterial cells in a salubrious environment, such as a moist soil, can flourish as happy, actively growing organisms that yield new cells and increase their population size. However, a cell can quickly find itself in a bad situation should its surroundings transform by unfavorable natural events, such as drought or influx of toxic compounds via rain water. In addition, human intervention with control measures, such as application of disinfectants, could devastate cell populations. While bacterial cells would die in harsh surroundings, those bacteria that exist as spores could prevail. Thus, the ability of the cell to transform back to its spore form, through the process of sporulation, can allow the organism to survive in ever changing environments.

Sporulation, as the process of a

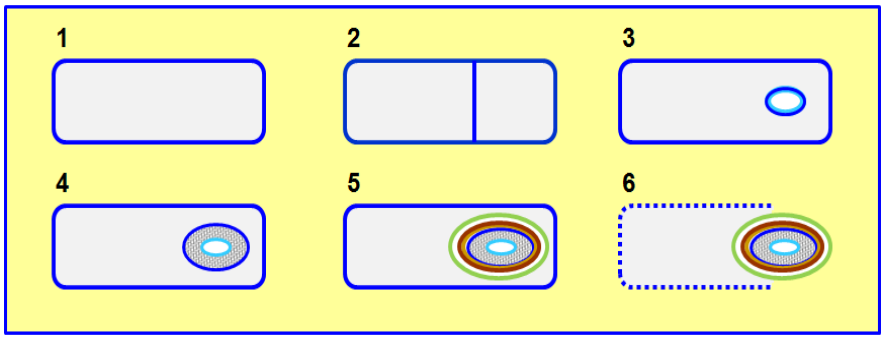

Figure 4. Process of *Bacillus anthracis* sporulation. 1: Cell in environment suitable for sporulation. 2: Septum produced to form mother cell (left region) and forespore (right region). 3: Septum reforms during assembly of membranes. 4: Cortex synthesis. 5: Coat and exosporium assembly. 6: Cell degradation and release of mature spore into the environment.

cell producing a spore, is typically initiated when nutrients of a spore's environment diminish. The cell can sense reduced levels of metabolic building blocks (such as carbon and nitrogen) and, if conditions are suitable, respond by producing a spore. By doing so, the organism charts its destiny to survive as a dormant entity in an austere environment. Alternately, if unable to sporulate, the cell could die in the harsh environment and, as a result, the microbial entity would be lost. As with germination, sporulation occurs as a sequential series of events resulting in formation of a new spore. Upon initiation of sporulation, the cell is transformed to operate its machinery to produce a spore within the cell. This transition is largely directed by genetic material in the cell, with genetic regions that lead to production of a spore being expressed. This process involves small molecules ("sigma factors") binding to an enzyme ("RNA polymerase") and, by doing so, enabling the enzyme to read specific regions of the genetic material that produces various components of a new spore. At the same time, genetic regions that direct a variety of the cell's activities are no longer read or expressed.

As depicted in Figure 4, the sporulation process involves structural changes within the cell, starting with formation of a membrane septum that divides the cell into a smaller section ("forespore"), in which the new spore forms, and a larger section ("mother cell") that nutures the new spore as it develops. After about three hours of spore development, the septum reforms as a spherical membrane structure in the forespore region of the cell. Through various synthetic steps, the spherical structure evolves to become a complete spore, with formation of the cortex, coat, and exosporium. The entire sporulation process can be completed in a few hours. In addition to occurring in natural environments, sporulation can be conducted under defined conditions in the laboratory. For a scientist to produce spores, cells are typically cultivated at 98.6°F in a flask containing a nutrient broth amended with specific metals. Under optimal conditions, almost every cell will produce a spore. At the end of sporulation, the cells lyse and the new spores are released into the broth environment.

The *Bacillus anthracis* Spore Casing as a Challenge to Biological Defense

As demonstrated by the "anthrax letter" attacks of 2001, the *Bacillus anthracis* spore as a biological agent can impose great challenges to biological defense. As mentioned above, the effort and cost required to decontaminate the stricken buildings is staggering. It is interesting to ponder the thought that the ramifications of the attacks were attributed, at least in part, to physiological properties associated with the bacterial spore casing. Protective layers allowed the organism to survive during release and exposure periods as well as persist in the building environments. In addition, the spore's disinfectant tolerance provided by the layers posed great challenges to experts tasked to select the best disinfectant and decontamination strategy. Thus, defense approaches that address spore casing properties could provide better protection in the event of another attack.

More effective control of *Bacillus anthracis* as a biological agent calls for scientific research focused on spore physiology. Understanding mechanisms of spore degradation by disinfectants or, perhaps, identifying the Achilles' heel of disinfectant attack could provide the basis to develop novel strategies for more effective decontamination. In addition, further knowledge of the spore could lead to devising treatments that unlock the protective casing and release nucleic acids for improved DNA-based detection sensitivity. Scientific findings could initiate new approaches to biological defense and improve response to a *Bacillus anthracis* attack.

As an alternate strategy for *Bacillus anthracis* control, a mild treatment was developed to disrupt the spore casing and thereby sensitize the spore to chlorine disinfection (Calomiris, 2006). Compatible with drinking water systems, the treatment appeared to activate the dormant *Bacillus anthracis* spore, disrupt the protective barrier, and allow spore death with lower disinfectant doses. The process offers potential for decontamination of sensitive materials or systems since spore disinfection could be achieved without harsh conditions. While this scientific finding is an example of a novel approach developed to improve biological defense technology, additional research is needed to more fully understand the *Bacillus anthracis* spore and advance defense capability.

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Pentomic Soldiers

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In today's long, grueling war against Al Qaeda and their ilk, American Soldiers enjoy plenty of popular support. Although only about 1% of our citizens serve in uniform, it's a rare public gathering that does not feature a salute to "the Troops." Athletes, singers, musicians, comedians, and actors put on shows and meet and greet, traveling gamely to the fetid Tigris River valley and the forbidding Hindu Kush. They follow trails blazed by luminaries like Bob Hope and Marilyn Monroe. Indeed, recently entertainers Mila Kunis and Justin Timberlake made two Marines very happy by accepting their invitations to the next annual Marine Corps Birthday Ball. Betty White, age 90, had to take a pass, but appreciated the offer.[1]

This is all certainly a welcome trend after the heartache of the Vietnam War era. But it is not without precedent. Not so long ago, American entertainers didn't just salute people in uniform, or date people in uniform. They were people in uniform.

In the decades after World War II, Uncle Sam gave many a chance to contribute, courtesy of a formatted telegram that always began with the cheery word: "Greetings." Facing off against the Soviet Russians, the U.S. Army needed plenty of able-bodied young men. The Army had trounced the Kaiser's Germans in the Great War, beaten the Nazi Germans and Imperial Japanese in the Second World War, and stood strong against the Red Chinese and North Koreans in the Korea War. Those veterans expected their sons to serve. They did.

The volunteers and draftees of the high Cold War, between 1953-1965, joined an Army that called itself Pentomic. The storied old regiments were gone, replaced by gleaming new "battle groups" of five companies (the "pent" part) backed by a high-tech menagerie of front-line nuclear weapons (the "atomic" part). The New Look Army deployed long range Redstone and Corporal missiles, shorter-ranged Honest John and Little John rockets, atomic artillery shells, and atomic land mines.[2] There was even a jeep-mounted pocket rocket called the Davy Crockett, in a simultaneous salute to the storied frontier marksman and the ubiquitous marketeer/Mouseketeer Walt Disney corporation that made the Tennessee legend a household name in the 1950s.[3] The idea was that in defense of West Germany, a battle group's five Pentomic companies would spread out and hurl their various nukes at the waves of advancing Soviet tank divisions. Energetic American commanders judged it a good way to fight outnumbered and win. The West Germans locals were not quite so enthusiastic about the idea.

The young Soldiers embraced it. From every state and territory, they reported for duty in their thousands. Even at the height of the draft, a great many volunteered, if only to get some say in their future. Among their number were three rather typical Pentomic Soldiers: Elvis Aaron Presley, James Marshall Hendrix, and Kristoffer Kristian Kristofferson. We know them better today as stars of American popular music. But back then, they were just doing their "hitch," holding the line when the Cold War was the coolest, daddy-o.

Armor: A Little Less Conversation, A Little More Action

Elvis Presley was a Cavalry scout. Born in Tupelo, Mississippi, Presley was 23 years old when he reported for duty at Fort Chaffee, Arkansas. Already a famous singer with thousands of adoring young female fans, Presley had the right approach: "The Army can do anything it wants with me."[4] And being the Army, it did.

After a one-day media madhouse disrupted Presley's basic training at Fort Hood, Texas, the Army wisely restricted access. The new private completed basic training, earned the specialty of Cavalry Scout, and went home on leave before heading to Germany. But unlike most of his fellow Soldiers, Presley stopped by a Nashville, Tennessee recording studio and knocked out several records. While he served in Europe, his shrewd agent released ten singles one after another, carefully spaced to assure maximum sales. Each made the top 40, including "Hard Headed Woman."[5] The Elvis Presley brand stayed very much in the public eye while the new Cavalry Scout served in Germany.

Some wanted the new private to join Special Services, a traditional route for celebrity Soldiers like athletes, singers, and actors. But Presley would have none of that. He had trained to be a Cavalry Trooper and that's what he wanted. He was assigned in accord with his training, like every other Soldier arriving in October 1958 aboard the troop ship USS *General George M. Randall*.[6]

On posting to the 3rd Armored Division ("Spearhead"), Presley joined the 1st Battalion, 32nd Armor in Friedburg. He was assigned to the Reconnaissance Platoon, and drove the platoon sergeant's jeep.[7] The battalion had the mission of defending the Fulda Gap.

From its base at Ray Barracks, Presley's platoon trained to deploy forward and screen the East German border. Multiple Soviet divisions waited just on the other side. It fell to Presley and his fellow Scouts to move up by Jeep, dismount, and

Sergeant Elvis Aaron Presley

provide early warning of any such invasion. Presley spent many weeks at ranges, on field maneuvers, and rehearsing the movements necessary to find the enemy—and exploit planned U.S. atomic bursts.

The rest of the battalion used big, heavily armed and steel-clad M-48 main battle tanks. But Presley and the Scout teams had unarmored ¼ ton trucks and a few machine guns. Their radios, however, and their observing skills would be crucial in the event the Russians came over. If an atomic shell had to drop on an advancing Soviet tank column, Presley and his fellow reconnaissance Soldiers would likely provide the map coordinates.

The new Scout was reportedly a model Soldier. Of course, he was also Elvis Presley. He lived in a nearby hotel with his father Vernon, and spent time now and then signing autographs for German fans. Presley donated his meager Army salary to charity. He used his much more ample record earnings to host parties, bought televisions for the battalion day rooms, and even purchased new uniforms for his fellow Scouts. The famous Soldier also met an Air Force dependent named Priscilla Beaulieu, age 14. They grew close. She became his wife in 1966.[8]

Presley made Sergeant the month before he returned home and received his Honorable Discharge. "I was in a funny position," Presley explained. "Actually, that's the only way it could be. People were expecting me to mess up, to goof up in one way or another. They thought I couldn't take it and so forth, and I was determined to go to any limits to prove otherwise, not only to the people who were wondering, but to myself."[9] He had done just that. For all the fame and adulation he achieved, he was a Soldier when and where his country needed him. When we salute those who held the line in Cold War Germany, we number Sergeant Elvis Aaron Presley among them.

Airborne: 'Scuse Me While I Kiss the Sky

Jimi Hendrix was a supply clerk. Born James Marshall Hendrix in Seattle Washington, Hendrix was 19 years old when he volunteered to join the Army's first purpose-built Pentomic formation, the 101st Airborne Division at Fort Campbell, Kentucky. Having seen a friend wearing the impressive Screaming Eagle patch, Hendrix wanted to see if he, too, could become a paratrooper. A nudge from a judge also played a role, as young Hendrix had been caught twice riding in stolen cars, although he himself was not the thief.[10]

Hendrix was not yet a prominent musician. He was a young black man in 1961 from the relatively tolerant Pacific Northwest. During basic training, he performed well enough to keep his requested skill as a supply clerk, a good thing, as he was the worst marksman in his platoon. Still, a black man in 1961 with a 120 aptitude score drew favorable notice. But that was at Fort Ord, California.[11] Scrutiny got tougher as he went south.

Young Hendrix of Seattle headed into segregated Fort Benning, Georgia for jump training, to be followed by a posting to Fort Campbell, located on the just as segregated Kentucky/Tennessee state line. He made it right through Airborne School, at that time four weeks in length for enlisted Soldiers.[12] He completed his five jumps, thereby accomplishing the one thing that mattered most to him about joining the Army.

Hendrix enjoyed parachuting. It was—and is—an unnatural act, a controlled fall from the sky. In their myths, the ancient Greeks lamented Icarus for daring such a feat and failing. But modern paratroopers train for it. The rush of air into the plane, the leap into the roaring wind, the disorienting spin of sky and ground, the opening shock, the gentle ride to the hard, hard ground—they all formed impressions that deeply influenced the budding guitarist.

Private First Class Jimi Hendrix

When Hendrix reported to Fort Campbell in November of 1961, the Army placed him as a repair parts supply clerk in the 801st Maintenance Battalion.[13] This organization tended and repaired the many weapons and vehicles in the division. Much

as he liked to jump, Hendrix did not care for the routine life of a supply clerk. Minor chores and handing out springs and switches did not seem like much of an Airborne adventure.

There were plenty of Screaming Eagles that were getting the full experience. The 101st Airborne's five Infantry battle groups trained to leap into the Soviet rear area. Allowing for the normal spread of parachute forces, the Airborne expected to be dispersed. Armed with Davy Crocket recoilless "hand gre-nuke" launchers, atomic land mines, and radios to call in a rain of nuclear Little John rockets, the paratroopers prepared to spread mayhem.[14] The rifle companies carried out a good number of parachute drops to keep proficiency. Meanwhile, Private First Class Hendrix handed out bolts and fan belts.

To add to the frustrations of a humdrum schedule, Hendrix and his fellow black paratroopers dealt with the harsh Jim Crow mentality that started just past the gate. He and fellow Soldier Billy Cox of Pittsburgh, Pennsylvania took the 45-mile trip to Nashville, Tennessee to play guitars and jam in black neighborhood clubs.[15] They both missed bed check now and then. Hendrix grew listless in his duties. His active mind drifted.

Although the Army was integrated, black Soldiers in 1961-62 sometimes drew more than their share of discipline. In the 801st Maintenance Battalion, white officers and sergeants had no time for Private First Class Hendrix. He was late. He was careless. He spent too much time in Nashville. First Sergeant Louis J. Hoekstra summarized: "His mind apparently cannot function while performing duties and thinking about his guitar."[16] In March of 1962, he received non-judicial punishment under Article 15 of the Uniform Code of Military Justice for missing bed-check, with a consequent reduction to Private. Two more Article 15s followed, and then by June of 1962, a general discharge characterizing him as "undesirable."[17]

Yet ex-PFC Hendrix had the last laugh. In 1967, Hendrix asked in one of his first big hit songs: "But first. . . are you experienced? Have you ever been experienced? I have." Most of his young fans, hippies and "straights" alike, thought he was talking about drugs. (And to some extent, he was.) But when questioned, the self-christened "Jimi" talked of what he felt during Army parachute jumps: ". . .once you get out there everything is so quiet, all you hear is the breezes."[18] Indeed.

His fellow Soldiers knew the deal. In Vietnam, Hendrix was the artist of choice out in the bush. He had been there. And nobody could ever take that away from him.

Airmobile: Sunday Morning Comin' Down

Kris Kristofferson was a helicopter pilot. Unlike draftee Presley or curious volunteer Hendrix, Kristofferson was born to be a Soldier. His grandfather fought in the Philippine Insurrection and rose to the rank of colonel. His father flew for the Army Air Forces in World War II and then the U.S. Air Force in the Korean War. The elder Kristofferson rose to be a major general.[19]

The younger Kristofferson was a prodigy. After graduating with top honors from Pomona College in California in 1958, he earned selection as a Rhodes Scholar. He majored in English literature and took an Army commission, which he deferred to complete his time at Oxford University. Kristofferson dabbled in music and singing while in England. But flying really got him interested.

When he came back to America in 1960, he made up quickly for his academic detour. "I volunteered for jump school and Ranger School and flight school, everything available," he recalled in a 1991 interview.[20] At about the same time Sergeant Presley was wrapping up his small role in screening the Fulda Gap, and Private First Class Hendrix was enjoying parachute jumps, Lieutenant Kristofferson learned how to fly helicopters.

Kris Kristofferson piloted the Huey helicopter for the Army

Rotary-wing Aviation was a key innovation for the Pentomic Army. When the Kristofferson's father and the new U.S. Air Force split off from the Army in 1947, the ground service was left with a few militarized Piper Cub light planes for artillery spotting. But the grim, ugly war in Korea showed the utility of a new flying machine: the helicopter, a very late entry at the end of World War II. Slow, ungainly, and bug-like in appearance, the early rotary wing craft were good at one very important thing—landing on razor-backed ridges and removing the wounded.[21] That was their forté in Korea.

The Pentomic Army of the 1950s saw real promise in these inelegant contraptions that flew close to the dirt. They could carry troops and light vehicles. They could elevate artillery observers and Scouts. They could even carry machine guns and rockets, and hover right above friendly Soldiers to rip up advancing foes. Best of all, the new Air Force, preoccupied with great, gleaming swept-wing bombers and hot-rod Century Series fighter jets, had very little interest in helicopters. Every Pentomic Division included almost forty helicopters.[22] Plans were afoot to build entire units around the new flying machines,

especially the very capable jet turbine UH-1 Iroquois, destined to become the redoubtable Huey of Vietnam lore.

Lieutenant Kristofferson entered Army Aviation in these seminal days. He ate it up. "I really enjoyed flying and firing at targets and things like that," he said later.[23] Like Elvis Presley, he wanted to get out and do something. Unlike Jimi Hendrix, he got his chance when he was ordered to Germany, to the 8th Infantry Division. Kristofferson benefited from all the flight time and young Aviator could want.

Of the major American combat forces in Germany, the 8th Infantry Division occupied the western-most positions, far back from the border. As such, the "Pathfinder Division" formed the primary U.S. Army counterattack punch once front-line elements like Elvis Presley's 3rd Armored Division chewed up the lead Soviet echelon. In the Pentomic fight, that meant the employment of dozens of atomic munitions. The 8th Infantry Division fully expected to be advancing over a smoking, cratered German countryside, edging around blown-down trees and avoiding known radioactive hot spots.

That's where Lieutenant Kristofferson and his helicopter could make a difference. In many ways, regardless of the assigned mission, Army Aviation always fulfilled the traditional Cavalry tasks of route and zone reconnaissance. They could invent their own high ground, cross rivers, ridges, and wreckage, and report back. Kristofferson flew many hours, always calling back with what he saw enroute. Despite some crisis periods and false alarms, the Russians did not come.

But the 8th Aviation Battalion kept looking and stayed ready. The new UH-1B Hueys and their older CH-43C Choctaw stable mates participated in every alert and exercise. The notoriously sketchy German weather included lingering morning ground fog, icing, rain and snow squalls, and unpredictable variations in each river valley. Instrument ratings were rare and night flying unusual. So the climate made it very tough. As one of the other 8th Infantry Division Aviators of that time put it, "It was said that one year flying in Germany was worth three years flying anywhere else."[24] Kristofferson served there from 1962-65, during the Cuban Missile Crisis and its tense aftermath. He was promoted to captain.

In 1965, Kristofferson volunteered for combat duty in Vietnam. The American effort there was ramping up, and with the advent of the 1st Cavalry Division (Airmobile), experienced Huey pilots were much in demand. But one particular Huey flier was also a Rhodes Scholar, and the Army decided that Kristofferson's talents were better used teaching cadets at West Point. Despite entreaties, orders were orders.

The Captain was not amused. In frustration, he resigned from the service. His first song was "Vietnam Blues," aimed squarely at college student draft resisters and anti-war protestors.[25] The general's son later evolved considerably, embracing many of the anti-war political views he once despised. But by and large, he eschewed politics and wrote songs about life. He acted in films. And he gained quite a bit of notoriety.

It's said that he got his break as a singer by flying a helicopter onto to the lawn of the Nashville estate of country music giant Johnny Cash. Kristofferson was flying for a civilian firm after his Army days. One weekend, he "borrowed" the corporate helicopter to make the delivery of his composition "Sunday Morning Comin' Down." Cash loved the song and the bravado.[26] The company fired Kristofferson. It didn't matter. He was on his way to stardom.

But he never forgot his Army service. In 1991, he addressed a concert crowd in the wake of America's first war with Iraq: "I want you to know I'm an Army brat; I was a captain in the Army and my brother was a jet pilot in the Navy. So I support our troops; I identify with them."[27] The hall erupted in cheers. The old Pentomic Soldier remembered.

Days of Future Passed

On their respective journeys to stardom, our country's three best-known Pentomic Soldiers each passed through Nashville, Tennessee, the center of America's recording industry. Each man adopted some form of rock and blues music, variously tinged by gospel, folk, country, and psychedelic influences. Despite wealth and fame, drugs, drink, and demons afflicted them all. In this regard, they were not much different from the society that bred them, nor the Army of the time in which they served.

Elvis Presley became the most popular music icon of his era. He starred in multiple hit movies, television specials, and concerts. Presley defined a look, an attitude, and a generation with a cascade of hit songs. His early death in 1977 only served to increase his popularity. His recordings still sell briskly as MP3 downloads, having outlasted vinyl, 8-tracks, cassettes, and compact disks. To many, Elvis Presley epitomizes American popular music of the latter half of the last century.

Jimi Hendrix served the shortest stint in the Army. His musical career was equally brief, ending in an untimely demise in 1970. Of the three, though, his work is most recognizably tied to the turbulent 1960s, particularly the fever dream of the Summer of Love of 1967 and the coincident Vietnam War raging on the far side of the world. Hippies and grunts alike listened and nodded. Hendrix was "experienced," all right.

Kris Kristofferson alone has lived to be an old Soldier. He still writes, plays, sings, and appears. His accomplishments include numerous songs, albums, movie appearances, and concert stage events. He doesn't pilot his own aircraft anymore. Still, he remains ever the restless Aviator, looking over the next ridge, hoping to tell others what he sees coming.

So five decades later we regard them, a Sergeant, a Private, and a Captain—one drafted, one volunteered, one commissioned—with experiences like those of millions of Pentomic Soldiers. But unlike the vast majority of their comrades, they left behind their thoughts in music and lyrics. In their art (and it is indeed that) you can hear the fading echoes, see the dim outlines, and feel the dried sweat of an Army long gone by. Thanks to three Pentomic Soldiers, it will not be forgotten.

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ENDNOTES

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22 Bacevich, The Pentomic Era, 108.

23 Jordan, "Kris Kristofferson."

24 Brigadier General Joseph W. Camp, Jr., U.S, Army, "Flying in Germany: A Company, 8th Aviation Battalion," www.usarmygermany.com, 2010, 8.

25 Hawke, "The Last Outlaw Poet."

26 Ibid. Johnny Cash used to claim that Kristofferson dismounted from the helicopter holding a beer. Although quite a heavy drinker at the time, the former captain demurred: "Do you know how hard it is to fly one of those things? I don't know how the hell I'd land one holding a beer."

27 Jordan, "Kris Kristofferson."

Pictures:
Jimi Hendrix - http://www.guitarmasterclass.net/wiki/index.php/Jimi_Hendrix

Elvis Presley - http://news.bbc.co.uk/2/hi/uk_news/scotland/glasgow_and_west/7361164.stm

Kris Kristofferson Huey Picture - Defense Image Digest

Enhancing Visualization of HPAC Scenarios using Google Earth©

Mr. Mathew Jackson
Nuclear Engineer, U.S. Army Nuclear and CWMD Agency

This article marks the beginning of a series of articles covering advanced techniques and resources that can be leveraged to assist the modeler in improving the quality of simulations. Our first topic focuses on expanding the capabilities of a widely used software package: Defense Threat Reduction Agency (DTRA)'s Hazard Prediction and Assessment Capability (HPAC). HPAC is a software package used by numerous government agencies for consequence assessment, and is an invaluable tool when modeling Chemical/Biological/Nuclear/Radiation/High Explosive (CBRNE) scenarios. As a modeler, it is important to display this data in a way that gives the commander a clear view of the extent of the hazard and what major land areas or population centers might be impacted. While HPAC allows for a user to import and overlay satellite imagery, it can be a cumbersome task if multiple locations or large regions encompass a given scenario. As an alternative to using plots similar to those in Figure 1, this article will demonstrate how HPAC users can utilize Google Earth (http://earth.google.com/) to visualize their scenarios. The default Google Earth server on unclassified systems contains satellite imagery of almost every location in the world. Use of the default Google Earth server would prevent the inclusion of any classified data, but fortunately the National Geospatial-Intelligence Agency (NGA) has established their own Google Earth servers for use on classified systems. An up-to-date list of these servers can be found by searching for "google earth servers" while on a classified machine.

Environmental Systems Research Institute (ESRI) is the developer of the most popular geographic information system (GIS) tools in the world; their shapefile format is widely used throughout the GIS community. In order to visualize HPAC contours within Google Earth, the contours must first be exported to ESRI's shapefile format and converted to Google Earth's kml file type. The conversion of HPAC contours to shapefiles is covered in-depth within module thirteen of the Consequence Assessment Tool Set (CATS) level 1 training material, but is briefly outlined below: after creation of a contour with HPAC 5.0, right click the contour and a tooltip menu will appear, from that menu select the next to last entry (which corresponds to the title of the graph) and choose "Export". The HPAC export dialog box should appear. Click the drop down menu next to "Files of Type" and select "ESRI Shapefile(*.shp)" from the list. Choose a file name and save.

Figure 1. Example of HPAC Contour.

After the HPAC contour has been converted to shapefile format, it can be used in GIS software. Those with a licensed copy of ArcGIS can utilize the ESRI script located at http://arcscripts.esri.com/details.asp?dbid=14273 to convert the shapefiles to kml. As an alternative to purchasing ArcGIS, an open source GIS tool, MapWindow (http://www.mapwindow.org), can be coupled with a $30 plug-in, Shape2Earth (http://www.mapwindow.org/downloads/index.php?show_details=29), to convert the shapefiles exported from HPAC to kml. Advanced users familiar with coding in C who wish to develop their own conversion script may find the shapefile C library (located at http://shapelib.maptools.org/) useful. Briefly described below is the process to import shapefiles into MapWindow, and export them as a kml file usable in Google Earth.

First, select File->Open from the MapWindow main window, then select ESRI shapefile from the file type menu circled in red (hit enter figure 2). Navigate to the location where the shapefile exported in HPAC was saved, select the file, and click Open.

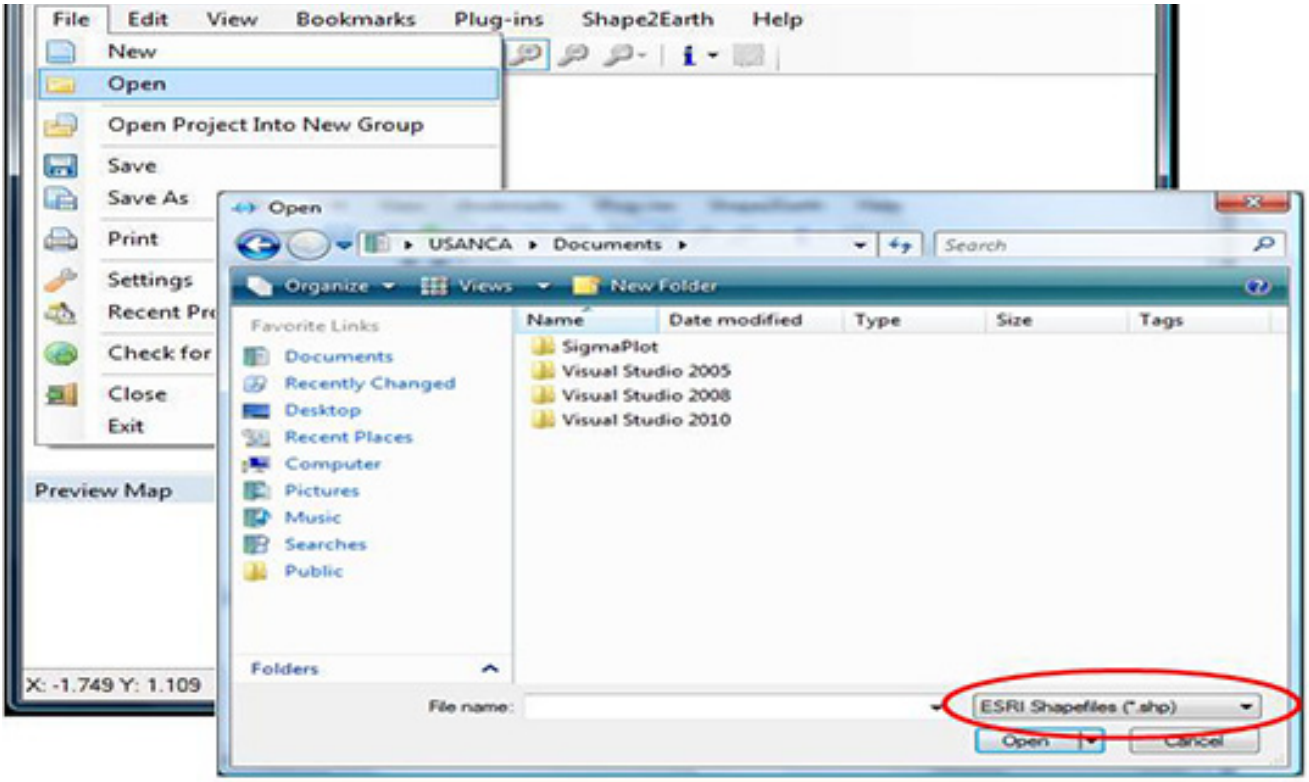

Figure 2. MapWindow Open File Dialog

The plot of your shapefile will likely be a single color; this will need to be corrected so it graphs correctly in Google Earth. First, one will see a single data layer listed inside the legend section. Highlight the section and click properties.

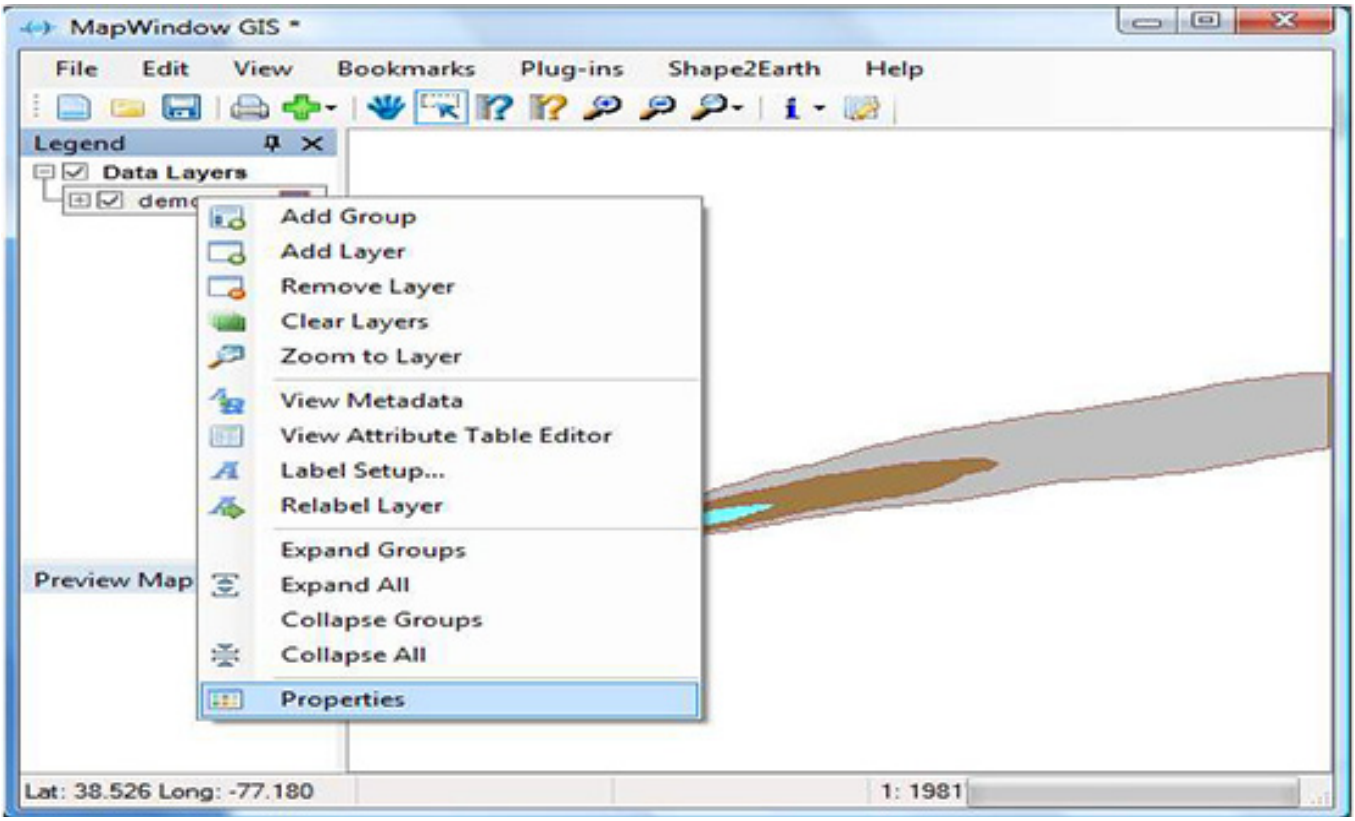

Figure 3. MapWindow Main Dialog: Properties Selection

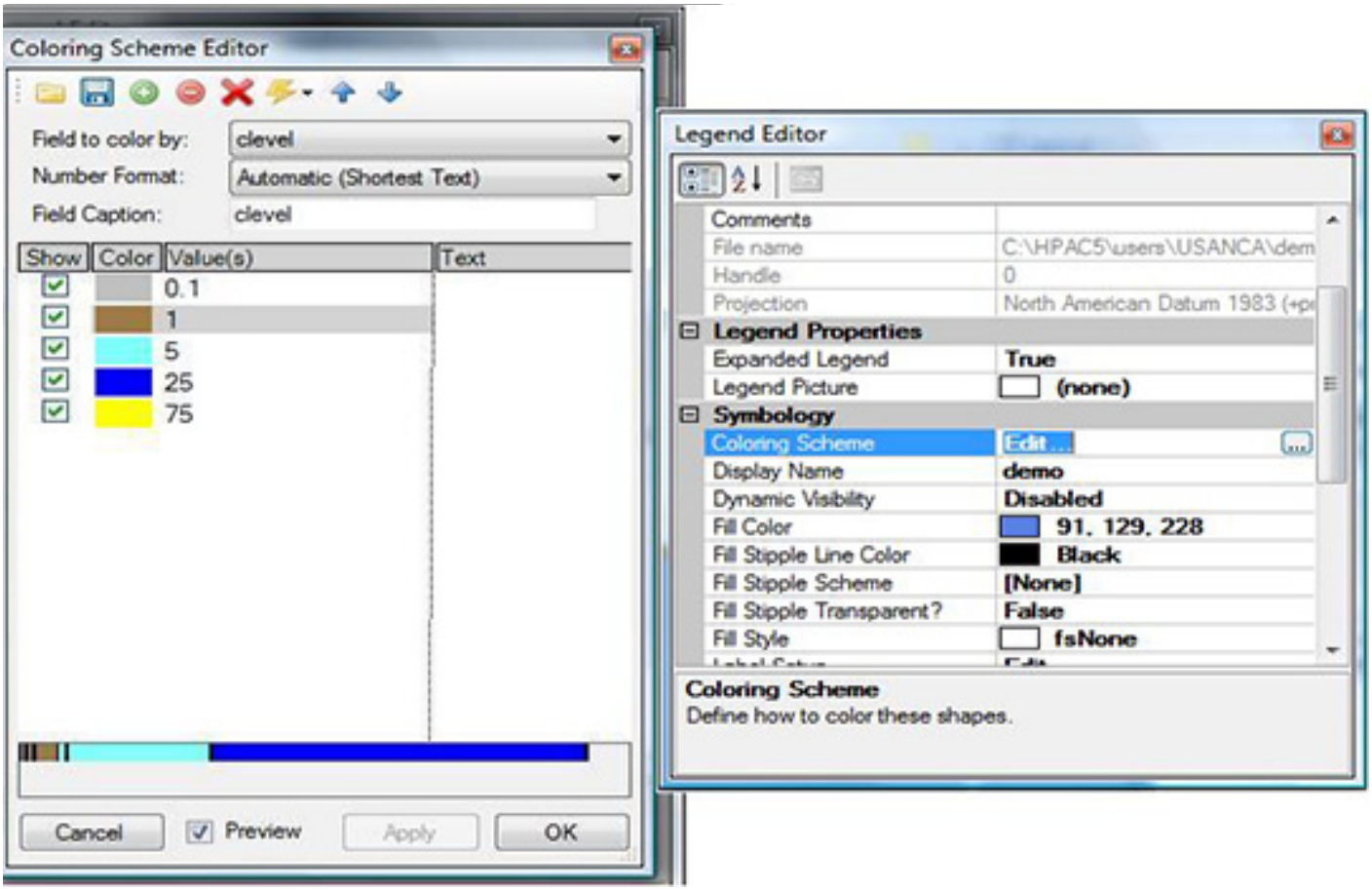

Figure 4. Properties Tab and Color Scheme Editor

Unfortunately, MapWindow by default does not know how to color the contours. To set the contour color levels select the button labeled " " next to the "Edit…" entry in the properties menu (figure 4). This brings up the Coloring Scheme Editor (figure 4), where the contour levels can be set and labeled as needed. The important thing to note is that clevel must be selected as the "Field to color by" property. If desired, the contour levels/color selected can be saved for use in later projects by clicking on the disk icon within the Color Scheme Editor. Once all color levels have been set, the Shape2Earth plug-in can be used to export the contour to a kml file (figure 5).

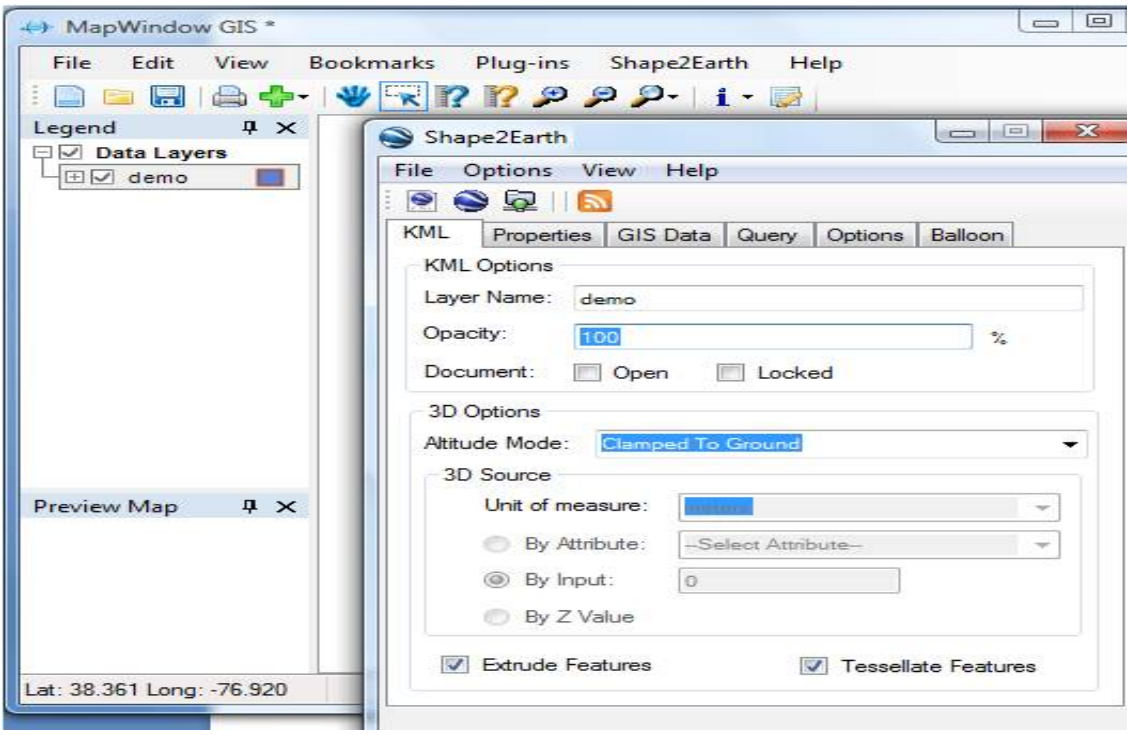

Figure 5. Shape2Earth Export Window

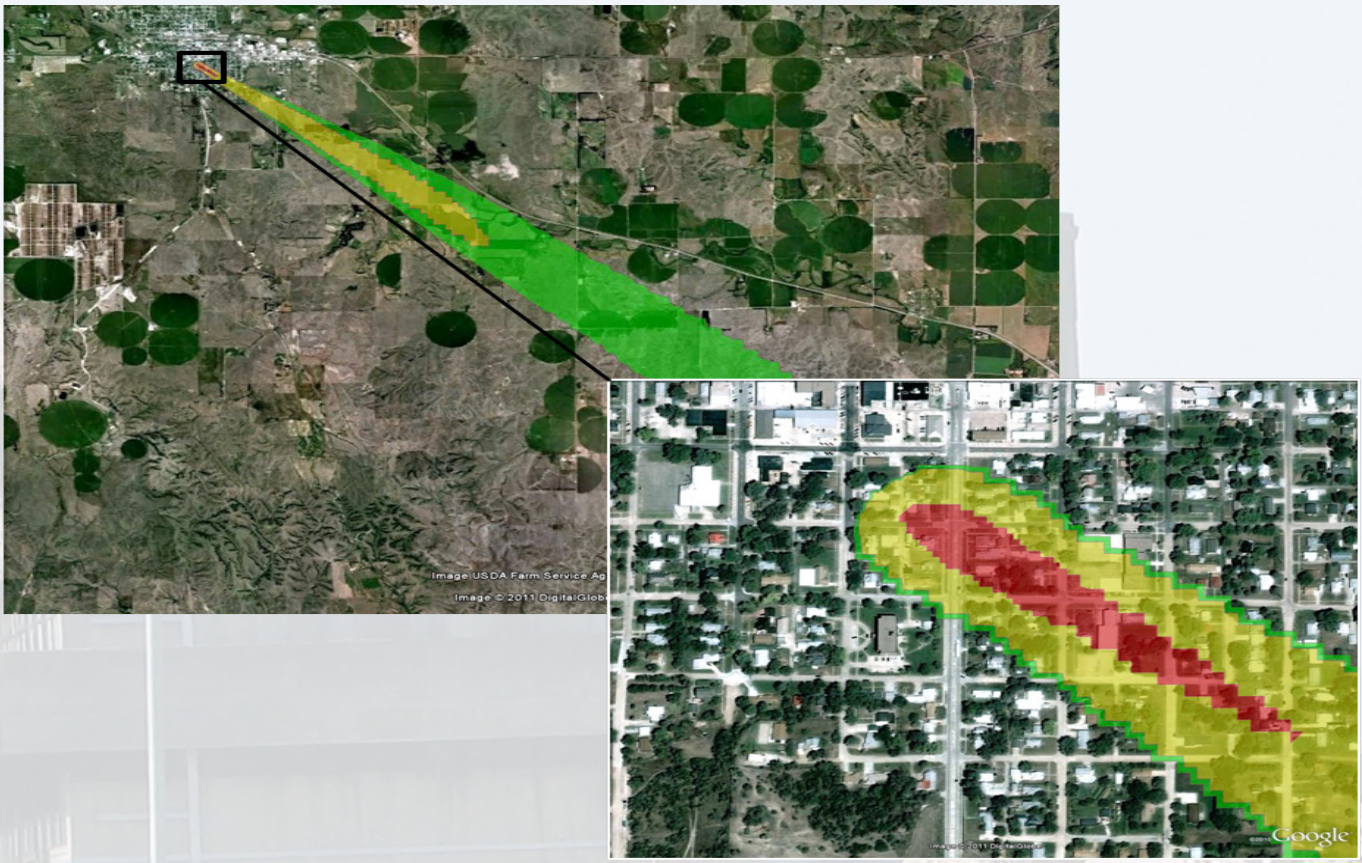

Figure 6. HPAC Contour Imported into Google Earth (©2010 Google, ©2011 DigitalGlobe, USDA Farm Service Agency

One entry to note is the opacity setting: this should be set at 40-60% if the terrain contained within contours is to be visible. The Properties tab allows for the creation of labels for the contours as well, the locations of these may need to be tweaked within Google Earth since it appears that Shape2Earth places the labels at each contour's center of mass. When all options have been set, select File -> Export -> SaveAs KML/KMZ. Finally, browse to the location of the KML file and double-click. Google Earth should open and zoom to the relevant region. As an example, a source was placed in a city, modeled with HPAC, and exported to Google Earth, as outlined in this article. With a little manipulation in PowerPoint and MS Paint one ends up with figure 6.

This is just one way that a modeler can use Google Earth to expand the capabilities of existing modeling software. The next article in this series will discuss the how a modeler can use Google Earth to view prompt effects and apply shadowing techniques to compute line-of-sight calculations from Google Earth polygons for more realistic modeling of thermal effects in urban landscapes.

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U.S. - Russian Partnership and the Plutonium Production Reactor Agreement

MAJ Kevin J. Owens

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Overview

Dr. Martin Luther King, Jr. once said, *"We may have all come on different ships, but we're in the same boat now."* This statement astutely represents the current conditions between the U.S. and Russia, as well as each country's nuclear weapons program. One significant and cooperative measure being executed between the United States and Russia is the monitoring of each country's plutonium production facilities.

The PPRA is now in its thirteenth year and continues to be a vital component for monitoring plutonium production facilities in the United States and Russia. It is a bilateral agreement that applies to 14 plutonium reactors in the United States and 13 Russian plutonium reactors in existence at the time the agreement was signed that requires the cessation of plutonium producion for use in nuclear weapons. This is achieved through monitoring to ensure that shutdown plutonium production reactors in both countries do not resume operations. A list of the reactors and locations are cited in Table 1. *These three recently shut down Russian reactors will be transitioned to the established PPRA monitoring regime to ensure they remain permanently shutdown.

The United States and Russia are permitted to conduct monitoring visits once a year at the other's shutdown reactors. During these visits, personnel visually inspect and observe placement of seals on plutonium oxide storage containers to ensure material is not used in weapons. The United States also has the right to monitor two of Russia's plutonium storage facilities in Seversk and Zheleznogorsk, twice a year.

U.S-Russia cooperation on nuclear nonproliferation and continued monitoring of weapons grade plutonium sends a positive signal to each country and to the international community. Since the end of the Cold War, the United States and Russia have worked toward a stronger partnership in the monitoring of each other's plutonium reactors. Developing strong partnerships and gaining an understanding of each other's nuclear material production complex have been instrumental in the success of the PPRA.

At the time of the signing of the 1997 Plutonium Production Reactor Agreement (PPRA), twenty-seven reactors in various stages of shutdown, dismantlement, or operation existed in the United States and Russia. These plutonium reactors and their supporting facilities produced large amounts of weapons grade plutonium for use in nuclear weapons. All those reactors are now shutdown with the announcement made at the April 2010 Nuclear Security Summit that Russia's last plutonium producing reactor was shut down.

Agents of the PPRA

Department of Energy's (DOE) National Nuclear Security Administration (NNSA) serves as the United States' Executive Agent for the PPRA. DOE works in cooperation with Department of State and the Department of Defense's Defense Threat

The U.S. and Russian teams take a group photo after monitoring K Reactor at the Savannah River Site

Russian Federation (13)	Reactor Status	United States of America (14)	Reactor Status
Ozersk (5)		**Hanford (9)**	
A Reactor	Shutdown	B Reactor	Shutdown
IR-AI Reactor	Shutdown	C Reactor	Shutdown
AV-1 Reactor	Shutdown	D Reactor	Shutdown
AV-2 Reactor	Shutdown	DR Reactor	Shutdown
AV-3 Reactor	Shutdown	F Reactor	Shutdown
		H Reactor	Shutdown
Seversk (5)		KE Reactor	Shutdown
I-1 Reactor	Shutdown	KW Reactor	Shutdown
I-2 Reactor	Shutdown	N Reactor	Shutdown
ADE-3 Reactor	Shutdown		
ADE-4 Reactor	Shutdown	**Savannah River (5)**	
ADE-5 Reactor	Shutdown	K Reactor	Shutdown
		L Reactor	Shutdown
Zheleznogorsk (3)		P Reactor	Shutdown
AD Reactor	Shutdown	R Reactor	Shutdown
ADE-1 Reactor	Shutdown	C Reactor	Shutdown
ADE-2 Reactor	Shutdown		

Table 1: List of shutdown and current operational plutonium production reactors

Reduction Agency (DTRA) to share responsibility for PPRA monitoring. As an executive agent, NNSA ensures that weapons-usable plutonium in Russia (estimated to be at least nine metric tons) is placed in secure storage and remains accounted for until transferred to a disposition process.

Key contributors to the PPRA effort are also joint military service members. The U.S. Army assigns Nuclear Research and Operation Officers (Functional Area 52 Officers (FA-52)) to DTRA in support of the PPRA mission. These FA-52 officers offer a unique background with specialized training in developing national and military strategy, generating plans and policy recommendations, and providing interagency leadership in nuclear related combating weapons of mass destruction mission areas.

Also in support of the PPRA are subject matter experts (SMEs) from the United States, mainly from DOE's Pacific Northwest National Laboratory and the Savannah River Site. These SMEs are the backbone to the program because they have the operational knowledge and experience working with nuclear reactors and plutonium storage. DOE also hosts visits to the Hanford and Savannah River Sites, and to ensure an efficient visit, DTRA's personnel escort the Russian team members while they are in the United States.

Monitoring at the Savannah River Site

Since the inception of the PPRA, relationships have been a key element in the success of the program. For example, during the June 2010 monitoring visit at the Savannah River Site (SRS) in South Carolina, the U.S. and Russian teams worked very well with each other and demonstrated a common passion for the work. Everyone involved in the visit diligently conducted the monitoring for each facility. This type of continuous working relationship among the team members, developed through previous PPRA monitoring visits in the United States and Russia, is essential for sustaining an effective program.

The SRS visit began with a reception for the Russian team, followed by a day of rest to recover from the flight. "The mission is straightforward and we know what we need to do," explained Oleg Komkov, Russian Federation's Team Chief, who has been associated with the delegation since 2000. The next day, Russian and U.S. teams met informally to discuss the agenda for the week ahead. While on site, the two teams visited four reactors and specifically identified locations within the facilities that were identified as disabled. After monitoring the shutdown reactors, the Russian team developed their report and conducted an outbrief to discuss the visit and plans for the next monitoring visit.

After the monitoring visit at SRS, both teams proceeded to monitor the shutdown reactors at Hanford. Since the majority of the U.S. team members were not fluent in Russian, interpreters were used to communicate during the monitoring visit and away from the site. The facility SMEs (mainly from NNSA and SRS's Management and Operations Contractor, Savannah River Nuclear Solutions) provided the site-specific knowledge needed to facilitate the monitoring visit and were prepared to answer questions. It was apparent that the teams had done this before and were knowledgeable about the facilities.

DTRA's Deputy Team Chief MAJ Rich Nameth said, "I have gotten to know these guys and we work well together. It took a little while, but they are more comfortable with me now." This was MAJ Namath's last monitoring visit because he was

The U.S. and Russian teams monitor facilities at SRS during the PPRA visit.

preparing to transition into a new FA-52 assignment in Florida. It was also, therefore, important for MAJ Nameth during this visit to introduce new members to the Russians for continuity of future missions.

When asked about the relationships he has developed over the past ten years with NNSA, DOS, and DTRA, Mr. Komkov said, "It helps, of course, having personnel that are familiar with the program and process. This includes having the right technical representative, interpreters, and personnel to logically plan for the event." When asked about the significance of the event, Mr. Komkov said, "Our mission is important to verifying the stopping of plutonium production facilities for nuclear weapons." MAJ Nameth also noted that "this was one of the smoothest visits we have had and the Russians really enjoyed their visit."

Off-duty time was filled with activities that allowed the teams an informal way of getting to know each other better. The teams toured the Augusta Canal and also attended an Augusta Green Jackets baseball game. "Trying to explain baseball is more difficult than I thought," said DTRA Team Chief, LTC Jeffery Weston. This was a first time for the Russians to see baseball being played in the United States.

Recent United States - Russian Developments

As the program continues, it will be important to maintain the established relationships and to develop the skills and experience of new PPRA team members. Since the United States and the Russian Federation are expected to continue the monitoring visits, it will be equally important for both to continue a positive working relationship. Working together and understanding each other's nuclear program will allow them to build even stronger partnerships in the future.

A significant and positive development that recently occurred in Russia was the shutdown of the ADE-2 reactor. Russia announced on April 15, 2010, the formal shutdown of the reactor in the Siberian city of Zheleznogorsk, which is 2,500 miles east of Moscow. The production complex was founded in 1950 on the orders of then Soviet General Secretary Joseph Stalin. During a 47-nation nuclear summit, hosted by President Barack Obama in April 2010, Russian President Dmitry Medvedev pledged to close the reactor.

Prior to the summit on April 8, 2010, President Obama and President Medvedev signed the New Strategic Arms Reduction Treaty (New START). New START is another significant example of the cooperative effort between the United States and Russia. The signed treaty was approved on September 16, 2010, by the U.S. Senate Committee on Foreign Relations and the full Senate approved it on December 22, 2010. Following the Foreign Relations Committee's approval, Senate Majority Leader Harry Reid said, "The New START Treaty that the President signed with Russia in April re-establishes U.S. leadership on global non proliferation of nuclear weapons, reduces Russia's nuclear arsenal, and takes concrete steps to secure a nuclear-free world without sacrificing America's security. I am pleased that the Senate Foreign

The group enjoys a cruise in the evening on the Augusta Canal.

President Barack Obama hosts the 47-nation summit in Washington.

Relations Committee passed this historic agreement with strong bipartisan support today . . . [and] I look forward to bringing this treaty to the floor."

Conclusion

The PPRA is a non-proliferation agreement between the United States and Russia. It fosters a cooperative effort for the cessation of plutonium production for use in nuclear weapons, and is reliant on a strong partnership and mutual understanding of both countries' nuclear weapons production complex. Although small in size, the U.S. and Russian teams of 21 personnel at the Savannah River Site during the week of June 7 11, 2010, made a positive impact in continuing this agreement for now and for the future. Partnerships and relationship are not built overnight and will require an effort from both countries.

"The past is prophetic in that it asserts loudly that nuclear wars are poor chisels for carving out peaceful tomorrows. One day we must come to see that peace is not merely a distant goal that we seek, but a means by which we arrive at that goal. We must pursue peaceful ends through peaceful means." (Martin Luther King Jr.)

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Exercise "Poets Corner" a Multinational Effort to Prevent CBRNE Terrorism

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Background

"Poets Corner" was the biennial Technical Response Group Capabilities Exercise (TRG-CAPEX) which consists of chemical, biological, radiological, nuclear, and bulk high yield explosives (CBRNE) law enforcement and military members from Canada, Australia, the United Kingdom, and the United States. The TRG shares

UK Fire Service College Location.

techniques and procedures, equipment updates and scientific advances among the other members as they relate to preventing or attributing CBRNE terrorism.

On a rotating basis, members of the TRG host a CAPEX. This year, the United Kingdom's Home Office sponsored the event. The CAPEX was hosted by the United Kingdom Police National CBRN (chemical, biological, radiological, and nuclear) Center and conducted at the National Fire Service College in Morton on Marsh, Gloucestershire, England from 21-26 March 2011.

The American, British, Canadian, Australian, and New Zealand (ABCA) Armies Program was granted permission to send an observer team of subject matter expert observers to "Poets Corner". The team consisted of representatives from the United States, United Kingdom, Canada, and New Zealand. The team's goal was to observe and report on improvements in national and coalition force Joint, Inter-agency, Inter-governmental, and Multi-National (JIIM) CBRN sensitive site exploitation interoperability.

The ABCA observer team had the following objectives: 1) Observe the execution and develop lessons learned on the conduct of CBRN operations, 2) Use results to inform ABCA Armies future capability development and improvements in CBRN SSE, and 3) Coordinate with other Capability Groups within the ABCA Armies Program to share the information derived from the achievements of the observer team.

Exercise Methodology

Exercise "Poets Corner" was the largest CAPEX to date with over 100 law enforcement and military CBRNE personnel from Canada, Australia, the United Kingdom, and the United States. The exercise focus was technical response and forensic collection immediately following a chemical, biological, radiological incident during an event of interest such as the Olympics, World Cup, or political inauguration. The exercise consisted of three scenarios with nations rotating through each scenario. Each nation therefore conducted the scenarios independently of other participating nations. Each nation had the opportunity to observe other nation's equipment and tactics, techniques and procedures (TTPs) during the conduct of the exercise. "Poets Corner" enabled participants to:

- Detect the presence of a hazard.
- Defeat a hazard.
- Create a permissive working area.
- Enable fast forensic collection.
- Allow immediate after action reporting.
- Evaluation of team performance.

UK EOD soldier rendering safe a chemical dispersion device.

Scenario Descriptions

Each team was given 6.5 hours to complete each sceario. National umpires and evaluators provided country specific njects and arbitration as required. Biological scenario - In the lead up to a major sporting event, two custodial cleaners from a major laboratory were admitted to a hospital and one of the cleaners subsequently died of anthrax. Responders were dispatched to the laboratory and were required to gain access, locate, render safe the device and collect intelligence and forensic evidence. Intelligence gathered from the site indicated an attack at the venue of a major press conference. Responders then moved to a second location to gain access, locate and render safe the explosive biological device and collect forensic evidence. A simulant was used to provide positive lab readings.

Chemical scenario - Two terrorists were transporting chemical devices by train on two separate passenger cars. One of the devices broke, releasing agent, killing all of the people on one of the passenger cars to include one of the terrorists. The train stopped in a remote area. The second terrorist, on a second car, departed in the subsequent evacuation but left a second chemical device in a backpack on the train. Responders were required to gain access, identify the suspected agent, locate and render safe the devices and collect forensic evidence. Simulants were used to provide positive readings on detectors.

Radiological scenario - While attempting to construct a 'dirty bomb', terrorists accidently caused a gas explosion which partially destroyed the multi-story building where the bomb was being constructed. The building partially collapsed and first responders having detected a radiological source had alerted police to its presence. Responders were required to locate and identify the radiation source, render safe the improvised explosive device and collect forensic evidence. The realism of this activity was enhanced with the use of a live radiological source.

U.S. soldiers assisting FBI on decontamination line after initial entry.

Observations

Equipment. All four nations, both national police and military, used the same or similar pieces of commercial or military spec detection and identification equipment. The most common pieces of equipment were: The HazMat ID®, HAPSITE (GC/MS)®, AP2Ce, ICAM and Multi-Rae®. Individual protection equipment (IPE) ranged between national military versions of chemical protective overgarments to Tyvek® level B suits with corresponding hand and footwear. The S10 protective mask (or variant) was the most commonly used air purified respirator by teams other than the United States. Essentially all teams used equivalent types of IPE during the exercise.

Canadian Royal Mounted Police conducting initial evidence monitoring and photo documentation.

Command and Control. National police were the lead agency for all scenarios. All other agencies (military or fire) were in a supporting role and at times the control

of the areas was ceded to these agencies for mission specific functions (EOD or CBR reconnaissance), however, overall site control was always maintained by the police. Canada, Australia, and the United States all used a similar incident command structure to conduct site operations. The United Kingdom's incident command structure, in principal was similar, however there were enough differences in national procedures and terminology that would have made interoperability challenging.

Australian EOD Team preparing to make initial site entry.

Tactics Techniques and Procedures. All countries approached each tactical scenario in a similar fashion:

- Establishing control, structures, organization and layout.
- Search and incident procedures methodology.
- Evidence/Forensic collection.
- Decontamination procedures.
- Primacy of law enforcement command of the incident.
- Integration of Scientific Advisers and Subject Matter Experts.

UK EOD preparing to x-ray radiological dispersal device.

Conclusions

The TRG-CAPEX demonstrated the success of the groups sharing of techniques and procedures, equipment updates, and scientific advance. The TRG members conduct the exploitation of a CBRNE terrorism event with very little differences[1]. Similar equipment and TTPs not only strengthen confidence when sharing results between national agencies they set the stage for potential international interoperability.

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ENDNOTE:

1 Differences were based on national policies and laws such as military / police jurisdiction.

Combating WMD Resource Page

Highlighted Courses available at the Defense Nuclear Weapons School (DNWS) and Defense Threat Reduction University (DTRU)

Theater Nuclear Operations Course (TNOC)

TNOC is the only course offered by a Department of Defense organization that provides training for planners, support staff, targeteers, and staff nuclear planners for joint operations and targeting. The course provides overview of nuclear weapon design, capabilities and effects to include U.S. nuclear policy, and joint nuclear doctrine. TNOC meets U.S. Army qualification requirements for the additional skill identifier 5H. The course number is DNWS-R013 (TNOC). Call DNWS at (505) 846-5666 or DSN 246-5666 for quotas and registration information.

Next class availability:
22-26 Aug 2011

Nuclear and Counterproliferation Officer Course (NCP52)

NCP52 is the Functional Area 52 qualifying course. Initial priority is given to officers TDY enroute to a FA52 assignment or currently serving in a FA52 position. There is limited availability outside of the FA52 community. Please call the FA52 Proponent Manager at (703) 806-7866 to inquire on available seats.

Next class availability:
Jul - Aug 2012

Combating WMD Courses

The Defense Threat Reduction Agency hosts two Combating WMD courses, the Introduction to Combating WMD and Advanced Combating WMD.

The introductory course provides an overview of U.S. Government and Department of Defense strategy and policy relating to Combating WMD and instruction is focused around the three pillars of Combating WMD and the eight military mission areas.

The advanced course applies aspects of the Joint Operation Planning Process to Combating WMD related plans and operations. Both courses are taught using a combination of instructor-led modules and practical tabletop exercises. For more information on course dates and registration information, visit the Defense Nuclear Weapons School's website at: https://dnws.abq.dtra.mil. Mobile Training Teams are available upon request.

U.S. Nuclear Policy

This course covers U.S. Nuclear Policy and its history; reviews NATO policy; discusses nuclear deterrence: theory, principles, and implications; discusses instruments of national power and implications for nuclear weapons; reviews nuclear surety and intelligence; discusses nuclear treaties and arms control.

This course is taught at the Defense Nuclear Weapons School (DNWS) Albuquerque, New Mexico

Email: dnws@abq.dtra.mil
Fax: (505) 846-9168 or DSN 246-9168
Online registration:
https://dnws.abq.dtra.mil/StudentArea/Login.asp

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