Combating WMD JOURNAL
U.S. Army Nuclear and CWMD Agency
Issue 8 Winter/Spring 2012

SUSTAINING GLOBAL LEADERSHIP: PRIORITIES FOR 21ST CENTURY DEFENSE

JANUARY 2012

Fort Belvoir Nuclear Revisited in 2011

Heisenberg In Action - A Year Plus in the Life of the Nuclear Disablement Teams

Executing the DOD Executive Agent Role for Chemical and Biological Defense

The Continuing Nuclear Military Revolution

Benefits of Nuclear Survivability

Protection Factors of Combat Systems

Chemical Warfare: Part III

Biotoxins Used As Warfare Agents (Part I)

Nuclear Zero: World Peace or World Chaos?

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Advertisement for the US Chemical Warfare Service.
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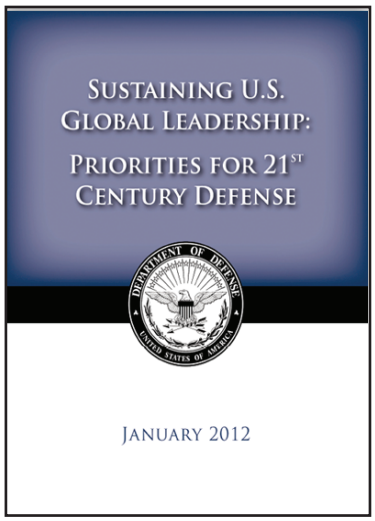
# New Strategic Guidance and CBRN Capabilities for the Joint Force in the 21st Century

Mr. Peter Bechtel
Director
U.S. Army Nuclear and CWMD Agency

The new strategic guidance articulate priorities for a 21st century defense to sustain U.S. global leadership, "*The Joint Force will be prepared to confront and defeat aggression anywhere in the world*." As we transition from today's combat operations, the U.S. will engage on a broader range of challenges and opportunities. As an enduring task, a 21st century Joint Force must succeed against ubiquitous chemical, biological, radiological and nuclear (CBRN) threats that could be used as weapons of mass destruction (WMD) anywhere in the world.




"Sustaining U.S. Global Leadership: Priorities for 21st Century Defense"

The new strategic priorities for a 21st century defense require the Joint Force to succeed in ten primary missions that DoD senior leaders consider most important for protecting and advancing U.S. core national interests. You, as a Nuclear and Combating WMD (CWMD) professional, will quickly notice that several of these primary missions directly impact the CBRN capabilities the Joint Force will need in the 21st century.

Adversaries will pursue asymmetric capabilities, including WMD, to complicate our operations and to counter our power projection capabilities. WMD proliferation will extend to non-state actors, as well. Given this anticipated environment, the Joint Force must be ready to operate in an extremely challenging environment. First, the Joint Force must deter and defeat aggression by any potential adversary, especially those armed with WMD. Second, it must project power despite anti-access/area denial (A2/AD) challenges, such as those from the asymmetric use of WMD. Third, the Joint Force must maintain a safe, secure and effective nuclear deterrent for the U.S. and allies as long as nuclear weapons exist. As a nation with vital interests in multiple regions, our Joint Forces must deter and defeat opportunistic regional adversaries even when our forces are committed elsewhere.

Combating WMD is fundamentally linked to a primary mission at the heart of our profession: the Joint Force must counter WMD by preventing the proliferation and use of CBRN weapons against U.S. Forces and allies. The Joint Force conducts a wide range of activities to prevent the proliferation and use of CBRN weapons. These activities include planning and operations to locate, monitor, track, interdict and secure WMD and WMD-related components and the means and facilities to make them. They also include an active national non-proliferation effort to frustrate the ambitions of nations or non-state actors interested in developing WMD. In partnership with other elements of the U.S. Government, DoD will continue to invest in Joint Force's capabilities to detect, protect against, and respond to WMD use, should preventive measures fail.

Finally, two more primary missions have direct CBRN implications that the Joint Force must be prepared to engage and succeed: defend the homeland and provide support to civil authorities, and provide a stabilizing presence abroad. The Joint Force must defend U.S. territory from direct attack from state and non-state actors, and provide support to civil authorities in the event that such defense fails. This is an enduring mission and we will address it in more details in future editions of the CWMD Journal. Likewise, the Joint Force must provide a stabilizing and sustainable presence abroad through deployments, bilateral/multilateral training exercises and building partner-capacity, especially for CWMD operations. The stabilizing presence provided by the Joint Force abroad is also an enduring mission with direct CBRN implications and closely related to the defense of the homeland and the maintenance of an effective deterrence.

Each of these primary missions brings a series of CBRN challenges and the need for capabilities to counter them; we will briefly highlight some of the most critical challenges and needs from the Unified Land Operations perspective.

The first critical CBRN challenge for Unified Land Operations is the need for actionable WMD intelligence. WMD intelligence challenges imply a basic need for near or real time intelligence from tactical to strategic level (for hazard avoidance, risk mitigation and targeting). This in turn demands the fusion and networking of multiple disparate data sources (sensors, databases and intelligence) for near real time hazard modeling and prediction. Early warning on the deliberate use or natural emergence of dangerous patho-

gens and other Biological Warfare Agents (BWAs) hinges upon the development of a global surveillance network that the U.S. can exploit. Enabling early warning, identification and continued situational awareness of existing or potential global threats is vital to protect the warfighter and for effective interagency response to prevent, protect and recover. Nevertheless, these efforts will fall short without a full Intelligence Community collaboration with labs and agencies to provide a complete common operational picture (COP).

Future WMD intelligence systems need to offer near real time, operational hazard prediction capabilities that include the fusion of indications and warnings, intelligence, environmental, operational, medical, and social media information. More specifically, these technologies must include networked COP employing a layered array of sensors, in conjunction with intelligence, surveillance and reconnaissance assets, to provide CBRN WMD intelligence updates in near real time. WMD intelligence technology must also enhance our ability to detect, collect, and analyze future warfare agents/radiological hazards in A2/AD environments. Finally, these systems must be predictive of selected regions and diseases for advanced knowledge of future pathogenic theater conditions.

The second critical CBRN challenge for Unified Land Operations is the catastrophic potential of BWAs and the rapid pace of bio-technology that enables BWAs production and proliferation. Challenges include differentiating between natural, accidental or deliberate exposure and development of corresponding advanced prophylaxes and broad-spectrum therapeutics against known and emerging threats. Additionally, the pressing needs for stand-off detection to reduce operational surprise, pathogen detection in water, personnel protection equipment (adaptable and scalable), personnel vaccination and vaccine stockpiling cannot be underestimated.

The BWAs challenge requires future technologies addressing real-time pathogen detection, forensics, and identification to alert commanders and assist medical personnel in assessing and responding to these threats. Portable detection equipment for austere environments, including airborne and water pathogens, and improved personnel protection equipment for passive defense must also rank high in technologies to develop. Finally, early detection and contamination avoidance are not sufficient to prevent exposure to BWAs, therefore it is essential to develop personnel, equipment and large weapon platform decontamination systems and associated joint standards that are feasible and sustainable anywhere the Joint Force must operate.

The third critical CBRN challenge for Unified Land Operations is the chemical warfare agents (CWAs) threat, specifically the Non-Traditional Agents (NTAs). NTAs challenges are many, but can be grouped in four basic categories: Detection and Identification (in all physical states); Protection (respiratory and ocular); Decontamination; and Therapeutics (antidote production and medical countermeasures). Future technologies to counter them include improved detectors, individual protective equipment, treatment protocols, and decontamination to enhance force protection. Given the intrinsic difficulties with detection of NTAs, it is important to develop "Smart" decontaminants that can be applied and removed by operators in the absence of autonomous, water-based decontamination operations.

The fourth critical CBRN challenge for Unified Land Operations is the threat of radiological hazards and nuclear weapons effects. Radiological and nuclear (RN) detection/identification is listed on the 2012 Chemical and Biological Defense Program (CBDP) Joint Priority List (JPL) given the need for breakthrough technologies in these areas remains critical to the Joint Force. In the most recent edition of the CWMD Journal, summer 2011, we discussed the need for Army's doctrine and equipment to further develop to address radiological and nuclear challenges. In the article "Putting R and N Back in CBRN," we described the challenges in this area and the positive steps that the Army has taken, but I also cautioned that "only through vigilance, renewed training on RN and an institutional adoption of prevention as a priority will the Army meets its responsibilities to the nation in combating nuclear and radiological weapons." This assessment remains valid today from the overall U.S. Unified Land Operations operational perspective on CBRN.

Ground Forces face extraordinary CBRN challenges to succeed on the primary missions assigned to the Joint Force in the new DoD strategic guidance. The ability to effectively operate in a CBRN environment is necessary, since operations in a CBRN environment will no longer be possible; they will be probable. Providing the nuclear and CWMD expertise in support of the Joint Force to succeed in these missions is our professional duty and an essential element for a 21st century defense to sustain U.S. global leadership in a strategic environment where CBRN threats are ubiquitous.

### Future - Unified Land Operations

Planning factors

- Ground forces should expect to operate in and provide effects within a CBRN environment
- CWMD missions are a part of and integrated into combined operations
- CBRN capabilities will continue to be a part of future Unified Land Operations structure

Potential CBRN Impacts

- Smaller US footprint per country over a larger operational area (stretching limited assets)
- Reduction or shifting of forward deployed US forces can increase response/support timeline
- Potental competition for resources in support of civil authority
- More austere environments (reduced access to water for decontamination
- Potental contamination of water and/or food as weapon
- Potental denial of access through contamination of Ports of Entry

Future Unified Land Operations Planning Factors and Potential Impact of Associated CBRN Challenges

# Biotoxins Used As Warfare Agents (Part I)

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**This article is modified from another paper written by the same author for "The First Responder", a newsletter of AristaTek, Inc., available at http://www.aristatek.com.*

## What Are Biotoxins?

A "biotoxin" is a poison produced by living organisms. The living organisms might be plants, animals, mollusks, fungi, microbes, or algae, for example. Over 400 biotoxins have been identified and many more exist in nature. The list includes ricin produced from the castor bean plant, snake venom, various toxins produced by bacteria, tetrodotoxin isolated from the livers of globe fish, aflatoxin produced by certain molds, cicutoxin from water hemlock, or histrionicotoxin from the skin of the poison arrow frog. The list is long. However the list is shortened to perhaps 15 or 20 biotoxins if we limit ourselves to those poisons which can be potentially used as weapons of mass destruction (WMD). Only a few biotoxins produced in nature can be mass produced and dispersed in the form of an aerosol which can be inhaled or sprayed onto surfaces and absorbed through the skin. Poisoning of food and water supplies is possible, but the poison would have to be mass produced and added to the food source or water supply. Some biotoxins are destroyed by cooking or by normal water chlorination, but other biotoxins are not easily destroyed.

Sometimes the U.S. military and other agencies may publish lists under the broad classification of bioterrorist agents or biological warfare agents. The list may include listings such as smallpox, pneumonic plague, anthrax, ricin, saxitoxin, abrin, and botulinum toxin. We need to make a distinction between a biotoxin, a disease-causing agent (a pathogen), and the disease itself. A biotoxin enters the human body or is produced within the human body by disease-causing microorganisms and does not replicate itself. The disease-causing microorganism replicates itself. The condition of being "sick" as the result of the disease-causing agent is the disease. For example, the microorganism that is responsible for the disease botulism is caused by the bacterium Clostridium botulinum which can grow in food under anaerobic conditions, or in the intestinal tract, or in wounds. The bacterium produces a biotoxin called "botulinum toxin". The disease botulism is caused by the biotoxin called "botulinum toxin" which is produced by Clostridium botulinum. We will limit our discussion to biotoxins.

### How Toxic Are Biotoxins?

Table 1, lists $LD_{50}$ values for laboratory mice (unless otherwise specified) injected with or inhaling selected biotoxins. The $LD_{50}$ value is the dose in units of micrograms per kilogram of body weight that results in approximately 50% kill of the test animal. Sometimes for inhalation the results are calculated as $LCt_{50}$ in units of mg/min/m$^3$ which are converted to $LD_{50}$ knowing the exposure time(s) and an estimated breathing rate of the test animals. The information was obtained from David R. Franz, 1997 (revised), "Defense Against Toxin Weapons", U.S. Army Medical Research Institute of Infectious Diseases, Fort Detrick, MD. Additional values were obtained from the U.S. National Library of Medicine Hazardous Substances Data Bank (HSDB) which cites peer-reviewed toxicology data, and other sources.

Incapacitation as well as lethality must be considered. Some toxins such as the T-2 toxin cause illness at doses many times less than the concentration required to kill.

| Biotoxin | Source | Molecular Weight | $LD_{50}$, µg/kg, unless otherwise specified | Reference |
|---|---|---|---|---|
| Botulinum toxin | Bacterium | 150000 | 0.001 (by i.p.) | 1 |
| Botulinum toxin | Bacterium | 150000 | 0.003 (by inhalation) | 2 |
| Shinga toxin | Bacterium | 55000 | 0.002 (by i.v.) | 1 |
| Abrin | Rosary Pea plant | 65000 | 4.5 mg/min/ft$^3$, $LCt_{50}$, rat, inhalation; $LD_{50}$ about 0.7 µg/kg | 3 |
| Abrin | Rosary Pea plant | 65000 | 0.01 (by i.v.) | 4 |
| Maitoxin | Marine dinoflagellate | 3400 | 0.13 (by i.v.) | 5 |
| Ciguatoxin | Fish marine dinoflagellate | 1000 | 0.40 (by i.p.) | 6 |
| Batrachotoxin | Arrow poison frog | 539 | 2 (subcutaneous) | 7 |
| Ricin | Castor Bean (plant) | 64000 | 4 (by i.p.) | 8 |
| Ricin (1 micron) | Castor Bean (plant) | 64000 | 3 (by inhalation) | 9 |
| Ricin | Castor Bean (plant) | 64000 | 1000 to 20000 (by ingestion) | 10 |
| Tetrodoxin | Puffer fish | 319 | 8 (by i.p or subcutaneous.) | 11 |
| Saxitoxin | Marine dinoflagellate | 299 | 10 (by i.p.) | 12 |
| Saxitoxin | Marine dinoflagellate | 299 | 263 (by ingestion) | 12 |
| Saxitoxin | Marine dinoflagellate | 299 | 0.9 (by inhalation) | 13 |

Table 1. Comparative Lethality of Selected Toxins in Laboratory Mice

By comparison, the $LD_{50}$ value (mice) for the chemical warfare agent Sarin is 150 to 180 µg/kg (by injection), 1000 µg/kg (dermal), or $LCt_{50}$ of 540 mg/min/m3 by inhalation (one-hour exposure) . For the chemical warfare agent VX, $LD_{50}$ is 22 µg/kg (subcutaneous injection). On a per unit weight basis, some biotoxins are more potent than any of the synthetic chemical warfare agents.

**How Do Biotoxins Act on the Human Body?**

Toxins can be classified by the mechanism of toxicity. The two broad classifications are cytotoxins and neurotoxins.

1. Cytotoxins cause cellular destruction

2. Neurotoxins affect the central nervous system. Death is usually caused by paralysis of muscles of respiration. Neurotoxins may act as presynaptic or postsynaptic neurotoxins, or both. The mechanism of action may be an ion-channel binding toxin, the ion being sodium, potassium, or calcium, which blocks the ion channel by binding to or occluding the extracellular (cell membrane) pore opening of the channel. Alternatively, the neurotoxin may act as an ionophore, which facilitates the transport of ions across cell membranes, e.g., by combining with the ion or increasing the permeability of the membrane. The neurotoxin may bind externally to nerve terminals and intracellular blockage of acetylcholine secretion as in the case of botulinum toxin.

Ricin is an example of a cytotoxin. T-2 Toxin is a cytotoxin which causes bleeding. Saxitoxin is a neurotoxin that acts as a selective sodium ion channel blocker and also inhibits the release of acetylcholine at nerve terminals. Tetrodotoxin is another example of a sodium ion-channel neurotoxin. Ciguatoxin (from fish contaminated with a dinoflagellate) is a sodium-ion binding toxin. Batrachotoxin affects the nervous system by causing depolarization of nerve and muscle fibers by increasing sodium ion permeability of the cell membrane.

**How Might a Terrorist Deliver a Biotoxin?**

The most likely method an aggressor might target military troops and civilian populations is as an aerosol, which allow the toxin to contact the inner surface of the lung. There are major technological problems that the aggressor must overcome. None of the biotoxins form gases or liquids that vaporize. All of them are solids (typically powders) which must be delivered as an aerosol usually by slurring in a liquid, e.g. a saline solution, perhaps with additives to prevent particles from clumping. To be most effective, the aerosol particle should be between 0.5 and 5 microns in diameter to be captured by the lung surface. Particles larger than 15 to about 20 microns fall harmlessly to the ground. Particles between 5 and 15 microns may lodge in the nasal passages and trachea and therefore are not as effective as when lodged in the lungs. A substantial portion of particles less than 0.5 microns in diameter will be exhaled and not retained in the lungs.

Consider ricin which has a $LD_{50}$ aerosol toxicity of 3 µg/kg. Assuming the data obtained from mice also apply to man, a 70 kg man receiving a 3(70)/1000 = 0.21 milligram dose would have a 50% chance of surviving. The amount of ricin required to achieve this dose over a one kilometer square area is estimated to be about 80 kilograms.[1] This assumes that the ricin is emitted as a respirable aerosol near the ground. Even though ricin is very toxic, there are technological problems in covering a large surface area with the toxin.

With botulinum toxin, less quantity is required. Botulinum has a $LD_{50}$ of 0.003 µg/kg. We are now talking of about 80 grams of botulinum toxin to cover a one-square kilometer area.[1] Again, this is assuming that the right-sized aerosol diameter is produced, the aerosol is delivered uniformly over the area, and meteorological conditions are ideal.

Some biotoxins result in incapacitating illnesses at levels much below the LD50 dose. An example is staphylococcal enterotoxin B which causes illness at very low dosages (vomiting and diarrhea). The LD50 by inhalation is 0.027 mg/kg (mouse). Staphylococcal enterotoxin B is a cytotoxin that causes the body to release large amounts of its own chemicals and fluids.

Trichothecene mycotoxins in low dosages cause skin lesions and systemic illness without being inhaled and absorbed through the respiratory system. The most likely route of exposure is through the skin. A dose of one-billionth of a gram per square centimeter of skin is sufficient to cause irritation of the skin. A dose of one-millionth of a gram causes destruction of skin cells (necrosis). Microgram dosages can cause irreversible injury to the eye. The $LD_{50}$ dose for one of the mycotoxins (T-2 Toxin) is 1210 µg/kg.

An assassin could target an individual by injecting a biotoxin-contaminated pellet. An example is Bulgarian exile Georgi Markov who was apparently killed by a ricin-containing pellet (estimated 0.28 milligrams of ricin) injected in his thigh in London in 1978.

**What about Contamination of Food and Water Supplies?**

Fortunately, there are a number of factors that work against massive contamination of public food and water supplies. Normal water chlorination will destroy bacterial toxins, for example, 5 parts per million of chlorine for 30 minutes destroys botulinum toxin. Water chlorination at these concentrations is ineffective against ricin, saxitoxin, T-2 mycotoxin, or microcystin. Cooking food will also inactivate some biotoxins but not others. Cooking fish or mussels typically will not destroy the biotoxins associated with

these foods.[2] Coagulation/flocculation at a water treatment plant will remove the higher molecular weight compounds/ proteins but is ineffective against ricin, saxitoxin, or other lower molecular weight compounds. Carbon adsorption or reverse osmosis water treatment removes most biotoxins, even the lower molecular weight compounds. Ingestion of most biotoxins is less toxic than inhalation.

**Diagnosis**

Responders and health care providers ask whether they may be able to tell the difference between a chemical warfare attack, a biotoxin attack, or a biological warfare attack using infectious agents. Radiation detection equipment is essential for detecting a dirty bomb attack.

The onset of incapacitating symptoms in a chemical warfare attack is almost immediate (within minutes). The onset may be a little longer if the chemical agent is absorbed through the skin. Chemical nerve agent poisoning is a violent illness resulting in respiratory failure, airway constriction, and increased body secretions (saliva and airway secretions), pinpoint pupils, perhaps also convulsions and muscle spasms.

Symptoms are almost always delayed in the case of a biotoxin attack or a biological warfare attack. There may be a delay of several days, even a week, from the time of exposure to an infectious agent to the time symptoms first occur. The delay could also be on the order of hours to two or three days in the case of a biotoxin attack depending upon the toxin and route of exposure. As expected, the delay is less if the toxin is inhaled. It is difficult, in general, to distinguish between a biotoxin and biological warfare agent attack. Diagnosis is based on specific symptoms and confirmation by laboratory tests.

Each toxin must be considered individually. Some toxins incapacitate so quickly that there would be little time for therapy after an attack. Fortunately, the potent bacterial protein toxins (e.g. botulinum toxin) act slower, and therapy is usually successful if started within about 12 hours after exposure providing the toxin is identified.

Identifying toxins or their metabolites in biological samples is very difficult because only a very small amount of toxin is required to cause illness. Therefore extremely sensitive assays are required. Furthermore, the biological samples must be collected soon after exposure or the molecules will be lost. The samples must be kept refrigerated until they can be analyzed as the toxin will be destroyed if stored at room temperature. Enzyme-linked immunosorbent assays (ELISA) of nasal swabs (collected within 24 hours after exposure) are definitive diagnostic tests for inhalation of biotoxins. They are sensitive to about 1 to 10 nanograms per millimeter and require about four hours to complete. The polymerase chain reaction technique provides a very sensitive means of detecting and identifying the genetic material of any living organism that might remain in the crude, impure toxin collected in the field.

**Protection**

Biotoxins are solids, usually a powder, which when weaponized are dissolved or slurried in a liquid (usually a water or weak alcohol solution) and then an aerosol created. Details on how to weaponize biotoxins are not available in the open literature, but information on aerosol production for pesticide application and also tests on producing aerosols for inhalation $LCt_{50}$ on test animals are published. Tight-fitting face masks can protect emergency response personnel. Eventually the aerosol will settle on the ground or on surfaces. Because toxins are not volatile, they should not pose a further threat (providing they are not ingested). An exception is the situation where the biotoxin also contains an infectious agent such as anthrax spores. Another exception is some mycotoxins (e.g. T-2) which are absorbed through the skin.

If the toxin contaminates skin and clothing, ordinary soap and water should remove almost all of the toxin.

**Recognized Biotoxins Which Pose a Severe Public Safety Threat**

Two of the natural biotoxins are classified as "Schedule 1 Chemical Warfare Agents" under the United Nations agreement on biological weapons, e.g. the Chemical Weapons Convention in 1993 and earlier agreements. These are saxitoxin and ricin.

On June 12, 2002, President George W. Bush signed into law the Public Health and Safety Act of 2002 (PL 107-188), which requires that the Department of Health and Human Services maintain a list of biological agents and toxins, which pose a severe treat to public safety. The list of biotoxins, as it appears in the August 23, 2002 Federal Resister, (see also 42 CFR Part 72, Appendix A) is as follows:

- Abrin
- Botulinum neurotoxins
- Clostridium perfringens epsilon toxin
- Conotoxins
- Diacetoxyscirpenol
- Ricin
- Saxitoxin
- Shiga toxin and Shiga-like toxins
- Staphylococcal enterotoxins
- Tetrodotoxin
- T-2 toxin

We will look at each listed biotoxin in upcoming articles. Ricin is discussed here.

**Ricin**

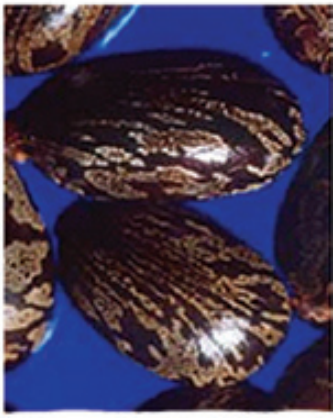
Ricin is a toxin extracted from the castor bean. The human fatal dose for ricin is about 1 to 20 mg/kg if ingested or about 70 to 1400 mg for a 70 kg adult. A castor bean might pass through the gut unscratched if its surface is not broken (as in chewing), but eight chewed castor beans contain

Source: University of Illinois

Source: Cornell University

Source: NPR Website, photo by Ketzel Levine

Source: Cornell University



Source: Wikipedia as used in USA Today website

Images of Castor Beans, Flowers, and Seeds

enough ricin to kill an adult and one chewed castor bean can kill a child[3] and about 0.05 milligrams if injected.[3] The lethal dose is much less in ricin is inhaled or injected (Table 1). Children are more sensitive than adults. Ricin acts by inhabitation of protein synthesis. Symptoms appear within a few hours after ingestion. The initial symptoms are abdominal pain, vomiting, and diarrhea (sometimes bloody). Within several days there is severe dehydration, urine decrease, and drop in blood pressure. If death has not occurred within five days, the victim usually recovers but suffers long-term organ damage. There is no specific antidote.

The castor bean plant (Ricinus communis) originally is a native of tropical Africa. It is now grown worldwide, sometimes as an ornamental in gardens or as a houseplant, and also grows as a weed in tropical and semitropical areas. The growing of the plant is not illegal, but in the United States (see Title 18, United States Code, part 175) a person caught manufacturing or possessing ricin may be sentenced up to 10 years, or life for possession with intent to use as a weapon or to provide to a foreign government.

Photographs and descriptions of the castor bean plant and its seed are readily available from the Internet making recognition easy. In tropical areas the plant can grow to almost tree-like size with up to 20-inch leaves. The leaves are usually eight-lobed as shown in the photograph with slightly serrated edges and prominent central veins.

Ornamental varieties grown in gardens may be purplish with narrower leaf lobes and smaller like the photo at the left. The flowers may be green or they may be pink or red as shown above (center). The soft flower capsules mature into soft spiked seed capsules each containing several mottled castor beans about 0.4 inch long.

More than one million tons of castor beans are processed each year to make useful products such as castor oil. Besides its use as a laxative, castor oil when dehydrated is used extensively in paints and varnishes, and is said to have qualities superior to linseed oil. Its water resistant qualities make it ideal for coating fabrics and for protective coverings. Other use is in the production of sebacic acid, which is the basic ingredient in the production of nylon. Castor oil has an ability to cling to very hot moving parts making it an outstanding lubricant for high performance engines.

Ricin does not partition into the castor oil product because the ricin is water-soluble. The ricin stays behind in the seed-pulp left over in oil extraction. The residual seed pulp (also called oil cake or pomace) may contain up to 5% ricin. The seed cake does make an excellent fertilizer. There are also numerous documented cases of ricin poisoning of horses or other livestock when they accidentally ate castor bean seeds or meal. Castor bean meal mixed in with bait is highly toxic to rodents and insects.

Procedures for extraction of ricin from castor seeds or seed pulp are said to be available on the Internet, and this author has not attempted to research these procedures. The trick is to separate the ricin from the other complex proteins, which form part of the castor bean, and a simple extraction using water (or lye or acetone) plus filtration does not accomplish this. Consequently homegrown recipes are likely to produce a mixture of plant proteins, and the ricin produced might even be partly denatured (inactivated). Another toxin from castor beans called “Ricinus communis agglutinin” is a powerful hemagglutinin (clumps red blood cells) but does not penetrate the intestinal wall. U.S. Patent 3060165 (granted in 1962, withdrawn in 2004) may be the basis of some procedures. As mentioned before, manufacture of ricin is illegal.

Mass spectrometry can be used as a method of forensic identifica-

tion of ricin including ricin in castor bean extracts. The procedure is described by Sten-Åke Fredriksson.[4]

Ricin is toxic by inhalation, injection, and ingestion. It is also absorbed by mucous membranes and the eyes. There is no known antidote. It is not readily absorbed through the skin. Symptoms of poisoning by ingestion may occur within a few hours, and include abdominal pain, vomiting, and sometimes bloody diarrhea (gastrointestinal hemorrhage). Within days, the victim experiences severe dehydration, decreased urination, and decreased blood pressure. Death occurs by shutdown of the circulatory system. Usually an otherwise healthy adult will recover if death has not occurred within five days, but could suffer organ damage. Based on table 1, the lethal dose for injection or inhalation is about 3 micrograms per kilogram of body weight assuming that mice data translates to humans. The lethal dose for ingestion is greater and depends on the body's ability to absorb ricin through the intestinal tract.

There have been attempts to weaponize ricin by governments, but because the material is difficult to deploy as an aerosol and is easily deactivated, historically it has not been used as a mass casualty weapon. However, the potential for use as a mass casualty weapon is there. Al Qaeda has reportedly experimented with ricin. Historically, specific individuals have been targeted. There are also a few incidents where powdered ricin has been sent in first class letters in the United States, including one sent to U.S. Senate Majority Leader in November 2003. An overview on Ricin and its potential role in terrorism is presented in a Congressional Research Service Report to Congress presented in December 2010.[5]

**Author Biographical**

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# Chemical Warfare: Part III

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This is the third article in a series detailing the history of chemical weapons that evolved into weapons of mass destruction and their role in our world today. Part I, CWMD Journal Issue 3, covers the development of chemical warfare (CW) from ancient times up to WW I. The article demonstrates how easily chemicals can be used in primitive inexpensive ways to create devastating impacts.

Part II, CWMD Journal Issue 4, covers CW during WW I. The use of chemicals in WW I ushered a new era known as *the age of modern chemical warfare*. As a result of the industrial revolution in the early 1900s, chemicals for killing were produced and disseminated on a massive and devastating scale. During WW I, post-war fatalities are estimated to be 4 times those of post-war conventional fatalities. Although pulmonary poisoning from chemical weapons was common, death was often the result of influenza (for example, the influenza pandemic of 1918), a major problem in WW I. Chemical toxicity as the result of inhalational or dermal exposure to agents often led to bacterial infection and death.[1] From WW I, CW was understood to be a dastardly effective game changer – the weapon of mass destruction before the nuclear age following WW II. While for humanitarian reasons, the international community pushed to ban CW use, nothing stopped the research race to improve chemical protective and offensive capabilities.

Part III examines the role of CW during the interwar years – the years between WW I and WW II (1919 to 1939). During this period, the United States Chemical Corps transitioned into the Chemical Warfare Service (CWS). Throughout the 1920s, rumors and newspaper accounts told of international chemical use and attacks. CW technology advances and offensive use continued despite the Geneva Protocol of 1925 banning chemical weapons first use. In the 1930s the Italians and Japanese used CW (primarily mustard) to significant advantage. CW tactics are covered by illustration of mustard use in these two conflicts. Most significant was the German development of G-series nerve agents in the late 1930s drastically reducing quantity and time to kill.

> CW is not singly for killing, but for physiologically breaking the will of an adversary by denying food, water or terrain and inflicting painful to deadly consequence to those without protection. Understanding past warfare chemical employment tactics aids in our planning for defense against it in the future. In the wake of Osama bin Laden's death, the instability of Middle Eastern countries possessing chemical weapons (i.e. – Libya and Syria), today's ease of individuals to make or obtain deadly chemicals – the threat of CW use by a rogue state or non-state actor has never been greater.

**The United States Chemical Warfare Service**

When the United States sent the American Expeditionary Force to France in 1917, the U.S. was largely unprepared for CW. The British and French militaries provided U.S. soldiers with protective gear and chemical munitions. Use of chemical weapons to break the deadlock of trench warfare led General Pershing to create a Gas Service. In September 1917, the U.S. Army formed the Gas Service with responsibility to train and equip our forces for protection and to use chemical offensive weapons (primarily British mortars and French 75mm artillery). On June 28, 1918, the U.S. War Department created the U.S. Chemical Warfare Service (CWS) that was executed by the following U.S. Government Departments and Army Corps: the Bureau of Mines (research and development); the Ordnance Department (production of agents and filling chemical shells); the Medical Department (procurement and supply of gas masks); the Signal Corps (procurement of gas alarms), and; the Corps of Engineers (offensive training and employment of gas).

**Advertisement for the US Chemical Warfare Service.**
**Photograph: Courtesy of the US Army Military History Institute, Carlisle, PA**

On July 1, 1918, MG William Sibert became the first director of the U.S. Army's CWS. The CWS, originally organized by the Army as a temporary war measure, was part of the National Army only, not the Regular Army. Its temporary status was due to expire within 6 months after the end of WW I (later extended to June 30, 1920).[2] However, if the CWS disbanded, the US Army would almost certainly forget the extensive experience of chemical offense, defense, and preparedness gained during the war.[1]

Two years later, July 1, 1920, Congress approved the CWS as a permanent part of the U.S. Army. Its mission included developing, procuring, and supplying all offensive and defensive chemical warfare material, together with similar functions in the fields of smoke and incendiary weapons. In addition, the CWS was responsible for training the Army in chemical warfare and use of special chemical troops. MG Amos Fries was the CWS chief from 1920 to 1929. The 1920s were lean years for the CWS. It averaged 400 enlisted and less than 1,000 civilian employees. Initially limited to train only its own troops in all aspects of chemical warfare, the Judge Advocate General ruled in May 1930 that both offensive and defensive training be allowed for all the Army.

During the interwar years, the CWS conducted research and development to ensure that the Army had credible chemical offensive capability as well as an effective defensive posture. The success of these programs helped prevent the use of chemical weapons in WW II.[2] However, it is speculated by others that early in the WW II, Germany could have used CW to great advantage; however, Hitler chose not to as his plan was to absorb fallen countries to peacefully join his cause. Later in the war, Germany lost air supremacy thereby becoming too weak to effectively deliver CW, even though their chemical weapons stockpile was vast. The United States had a no-first-use-policy regarding chemical warfare. The Allied countries practiced a similar policy. Chemical deaths and casualties from WW I served to remind both sides that CW use was a last resort.

The CWS expanded its battlefield capabilities with implementation of the 4.2 inch chemical mortar and smoke generators, which delivered smoke and high explosive munitions in support of combat arms missions. The CWS also developed and deployed a family of flame and incendiary weapons systems.

In 1942 the CWS undertook the responsibility for managing developments in biological as well as chemical warfare. On August 2, 1946, Public Law 607 changed the name of the CWS to the "Chemical Corps."[3] The Chemical Corps continued its work on improving chemical and biological offensive and defensive capabilities. In 1949 it was assigned the responsibilities of radiological warfare, giving the Chemical Corps the responsibility for Chemical, Biological and Radiological (CBR) warfare.[2]

**Interwar Chemical Use**

An international push to ban CW followed the conclusion of WW I. The Geneva Protocol of 1925 was essentially a "gentleman's agreement" for no-first-use, but even this was not adopted by the United States until March 26, 1975. The U.S. policy of continued CW preparation and retaliation in kind was viewed as the best deterrent. Hindsight has shown this strategy was effective for the U.S. in the 20th century. The Geneva Protocol, while well intended, did little to stop the advance of CW development, production and stockpiling. In fact, it was all too easy to claim wartime injustices for post-conflict use of chemical weapons.

Despite global movements to stop CW, rumors and reports of chemical attacks plagued the world news throughout the 1920s. During the Russian civil war and Allied intervention in the early 1920s, both sides possessed chemical weapons and reportedly used them on a limited basis. Isolated chemical attacks were also reported with accounts accusing the British, French and Spanish.[4] Post WW I, many countries began to develop formal chemical warfare capabilities and some put their capabilities to the test in live operations.

By the 1930s, many of the major powers had chemical programs and used or created stockpiles of chemical weapons. No international attempts to ban chemical warfare met any success in the 1930s. Chemicals were secretly used for wars in the name of imperial expansion, most notably by Italy and Japan. Both Italy and Japan had formal CW development programs that led to their use of CW in the late 1930s. These cases show the insidious nature of chemical warfare is not just the lethal and latently debilitating or fatal casualties, but the very real psychological morale-breaking damage amongst the fighting troops.

Italian-Ethiopian War (October 3, 1935 to May 1936). This engagement was considered the first major use of CW following WW I. Italy's dictator, Benito Mussolini launched an invasion of Ethiopia from its neighboring Italian controlled countries – Eritrea and Somaliland – that lasted 7 months. Italy had military superiority. The question was not if Mussolini's forces could secure victory, but when. The victory needed to come quickly before the world took notice and forced a preconclusive withdrawal. Mussolini used CW (predominantly mustard) to force an early conclusion. The conflict proved two things: 1) the ineffectiveness of the League of Nations (predecessor to the United Nations from WW II), and 2) the devastating effectiveness of chemical weapons against unprepared adversaries.[5]

**Ethiopia**

With air superiority, the Italians dropped mustard bombs and occasionally sprayed mustard from airplane tanks. They also disseminated mustard agent in powder form as a "dusty agent", on the African des-

**Ethiopia**

Courtesy of: World Atlas, http://www.worldatlas.com/webimage/countrys/africa/et.htm

ert sands in order to burn the unprotected feet of the Ethiopians. There were rumors of phosgene and chloropicrin attacks, but these were never verified. The Italians later justified CW use as reprisal against illegal acts of war that the Ethiopians had tortured or killed their prisoners and wounded soldiers. The chemical weapons devastated the unprepared and unprotected Ethiopians, who had few anti-aircraft guns and no air force.[6] Only decades later, in 1993, did Italy formally admit to using chemical weapons in the war.

Described to the League of Nations by the Ethiopian Emperor Haile Selassie's:

"Special sprayers were installed on board aircraft so they could vaporize over vast areas of territory a fine, death-dealing rain. Groups of 9, 15, or 18 aircraft followed one another so that the fog issuing from them formed a continuous sheet. It was thus that, as from the end of January 1936, soldiers, women, children, cattle, rivers, lakes, and pastures were drenched continually with this deadly rain. In order more surely to poison the waters and pastures, the Italian command made its aircraft pass over and over again. These fearful tactics succeeded. Men and animals succumbed. The deadly rain that fell from the aircraft made all those whom it touched fly shrieking with pain. All those who drank poisoned water or ate infected food also succumbed in dreadful suffering. In tens of thousands the victims of Italian mustard gas fell." [7]

The US Army closely followed the war with different assessments. From interviews with Italian soldiers and officers, one could be led to believe the use of chemical agents in the war was little more than an experiment, that mustard gas was not used extensively in the African campaign and its use had little if any effect on the outcome. The Italians claimed their machine guns and air force against the Ethiopians were the key elements.

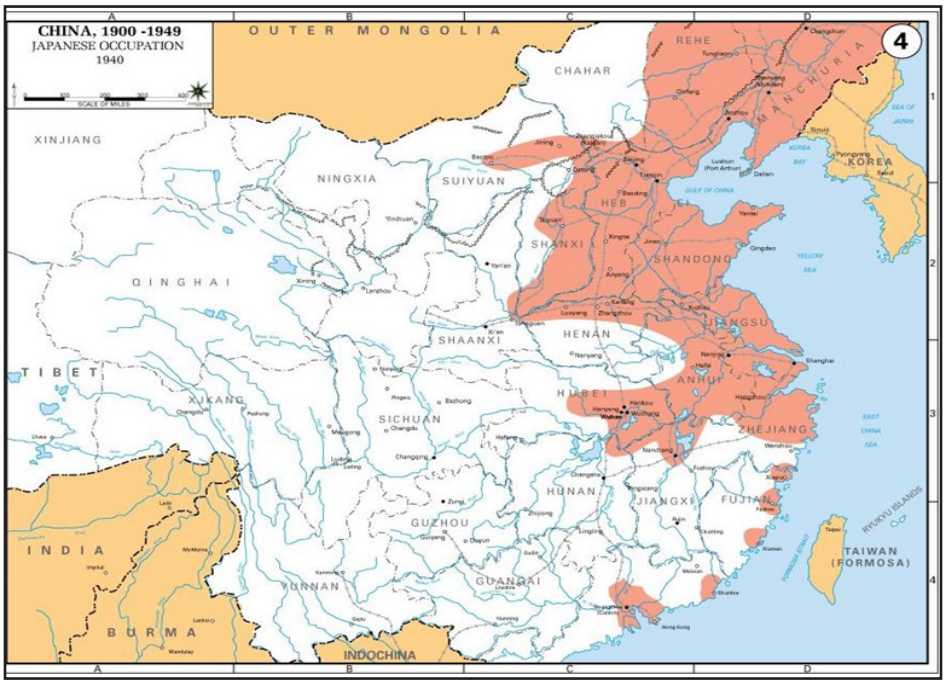
However, interviews with Ethiopians and analysis of effects gave an entirely different picture. Per US Army Captain Meade, "chemical weapons were a significant factor in winning the war. They destroyed the morale of the Ethiopian troops who had little or no protection. It broke any attempts at concentrating forces. Of all the weapons used, mustard gas was the most effective. It caused few immediate deaths, but temporarily incapacitated very large numbers and so frightened the rest that the Ethiopian resistance broke completely."[8]

MG Fuller assessed that Italian use of mustard agent protected the flanks of columns by denying ridgelines and other key areas to the Ethiopians. In place of the laborious process of picketing the heights, the heights sprayed with mustard gas were rendered unoccupied by the enemy, save at the gravest risk. It was an exceedingly cunning use of this chemical.[9]

Japan-China War (1937). The next war that drew the interest of chemical warfare analysts began when the Japanese invaded China in 1937. Tensions between the large population of China and the more technologically advanced Japan existed for decades. In addition to their biological warfare program, the Japanese had an extensive chemical weapons program and produced agent and munitions in large numbers by the late 1930s. During the war with China, Japanese forces reportedly began using chemical shells, tear gas grenades, and lacrimatory candles, often mixed with

smoke screens. By 1939 the Japanese had reportedly escalated to using mustard agent and lewisite. The weapons proved effective against the untrained and unequipped Chinese troops. The Chinese reported that their troops retreated whenever the Japanese used smoke, thinking it was a chemical attack.[5,10,11]

Chinese reports place the estimated number of chemical weapons used by Japan in this conflict around 2 million. About 670,000 abandoned Japanese chemical weapons are believed dumped or buried in the hilly plains of Jilin Province alone. Both Japan and China are working in cooperation to retrieve and environmentally dispose of these munitions.[12]




Courtesy of the US Military Academy, West Point History Department

There are several lessons we can take away from the mid-1930's Italian and Japanese employment of chemicals. The Italians tactic of using chemicals to deny their opponent terrain, food and water supplies still applies today. Also of note is how easy it was for Italians (as with the Germans in WW I) to find excuses to violate the first-use ban on CW. When later challenged, the Italians claimed CW was a retaliatory measure for Ethiopian atrocities to Italian prisoners. The Japanese cunning mix of multiple agents with smoke thus faking the appearance of chemical attack is yet another tactic to be taken from this review.

**Interwar Chemical Weapons Technology**

At the close of the 1920s, the U.S. CWS categorized chemical warfare agents into three levels of importance.

- Mustard (H, HS for Hun-Stoffe where (S) for 35% solvent added to form crude mustard and HD signifying distilled or purified mustard)
- Methyl Difluorarsine (MD)
- Diphenylaminechlorarsine (DM)
- Chloroacetophenone (AN)
- Titanium Tetrachloride (FM)
- White Phosphorus (WP)
- Hexachlorethane (HC)

Less important were:

- Phosgene (CG)
- Lewisite (L)

Least important were:

- Choloropicrin (PS)
- Chlorine (Cl).[13]

The most important work on new chemicals was done secretly by Germany in the 1930s (this information was not known by the allied powers until after WW II). Germany's work on organophosphorus compounds, G-series chemical agents, brought about the first nerve agents, cholinesterase inhibitors. While initially discovered in 1854 synthesized by Wurtz and tested by Clermont in 1854[14], their use for chemical weapons was not realized until Germany's efforts in the 1930s.

In the 1930s, Germany was in need of pesticides that could be made without the using petroleum, for oil was in very short supply. Dr. Gerhard Schrader was tasked by Dr. Bayer in 1934 to work on organic fluorides and other promising developments in organophosphates. In January 1937, a drop of an organophosphate-cyanide compound accidently fell upon a bench while Schrader was working. Soon, everyone in the room had constricted breathing and pin point pupils. After taking three weeks to recover, the research team understood that they had stumbled upon a highly toxic nerve agent with possible military applications. This was called "Tabun" (GA) originally code named "Taboon." In 1938, using the same basic carbon-phosphate chiral center, but using fluorine instead of cyanide became known as "sarin." Sarin (GB) was named after its inventors: **S**chrader, **A**mbrose, **R**udiger, and Van der L**in**de.[15] The G-series took CW to a new level of deadliness not again rivaled until the persistent V-series nerve agents were developed in the 1960's.

Dissemination. WW I used cylinders and wind dispersal initially followed by chemical shells. The 1920s brought about chemical projectiles with central bursters. The 1930s, aircraft bombs and crude spray tanks as demonstrated by the Italians in Ethiopia.

Protection. For protection, significant improvements were made to gas masks after WW I in the early 1920s. Edgewood Arsenal, Maryland, made the first gas

masks that could filter smoke providing protection against arsenic-based compounds.

Detection. Animals and noise makers were the practice in WW I. It was not until 1934 that the CWS was tasked with developing a field expedient detector. The fruits of that work were not realized until many years later.

**Closing Remarks**

In review of chemical warfare in the 1920s and 1930s, the most noteworthy item for chemical defense planning is the development of the G-series agents. The methods used by the Italians and Japanese in employing primarily mustard during the 1930s while not new, illustrate the possible application by hostile forces today. The key point of this discussion is how devastatingly effective CW use is against an unprotected population. In reality, the United States homeland is vulnerable to a CW attack at any level. This is because it is impractical to provide and maintain chemical protection and detection equipment for every person. However, the United States does the next best thing. There are intelligence efforts to identify and neutralize threats before they occur. Also, the Department of Homeland Security and DoD are prepared for rapid respond to domestic chemical incidents even though the public remains largely unaware and ill equipped.

The international memory of chemical atrocities from the WW I proved an adequate deterrent to both Axis and Allied employment of CW in WW II. However, this deterrent has little sway with terrorists. Furthermore, the international community continues to research to improve chemical offensive and defensive capabilities even today. Stay tuned to future issues of the Combating WMD Journal which will explore this topic further.

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**Correction**

Chemical Warfare: Part II had a table that listed the US use of 75 artillery shells of phosgene in Verdun, France on March 1916. This was done by Germany. The US did not fight in Europe until 1917.

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# Executing the DoD Executive Agent Role for Chemical and Biological Defense

Al Mauroni

In 1993, Congress directed the Secretary of Defense to designate the Army as an "executive agent … to coordinate and integrate research, development, test, and evaluation [RDT&E], and acquisition, requirements of the military departments for chemical and biological warfare defense programs of the Department of Defense."[1] This direction originated in a section of Public Law 103-160 (National Defense Authorization Act for Fiscal Year 1994), now codified as 50 U.S. Code, section 1522. It is better known as the act that consolidated all DoD chemical and biological (CB) defense RDT&E funding (except DARPA) into six defense-wide program element funding lines, to be managed by a single office within the Office of the Secretary of Defense (OSD). It also directed the Secretary of the Army to review all funding requirements developed by the Department of Defense's (DoD) Chemical and Biological Defense Program (CBDP). The 1993 public law was not the first mention of this DoD Executive Agent role. In 1976, DoD Directive 5160.5, "Responsibility for Research, Development, Test and Evaluation (RDT&E) on Chemical Weapons and Chemical and Biological Defense," identified the Army as the DoD Executive Agent, with the Services responsible for requirements development and procurement of CB defense equipment. In 1985, this directive was updated to clarify this responsibility in terms of joint requirements, updated budget procedures, and the development of chemical warfare agents for military purposes.

In executing the public law's direction, the three Service acquisition executives signed a memorandum of agreement in 1994 on how to implement the new joint program. Specific Army general officers were designated as chairs of a requirements committee and an acquisition committee, both populated by service action officers who had full-time jobs in other organizations. A larger oversight board, chaired by the Army Acquisition Executive and the Vice Chief of Staff of the Army and including flag officers from the other Services, presided over the annual development of the CBDP budget. Although the Army had most of the RDT&E infrastructure and majority of procurement requirements, a "one Service, one vote" rule effectively reduced the Army's equity to being equal to the other three Services. In addition, the action officers divided responsibility for managing the CB defense acquisition projects among the four Services. The Army's Executive Agent role was more facilitation than leadership.

By 2000, the need for a new management structure became painfully clear. Mid-level action officers were deciding the direction of the program, rather than the general officers who were appointed as principals on the committees. The program's funding had roughly doubled in size since its inception to more than $700 million a year. The DoD CBDP was not responsible for the DoD Domestic Preparedness Program, which executed a 120-city "train the trainer" program for U.S. cities preparing to respond to CBRN terrorist incidents.[2] It was not initially in charge of developing, certifying, and procuring equipment for the Weapons of Mass Destruction (WMD) Civil Support Teams. The Joint Program Office for Biological Defense ran its projects as an effort distinct from the Army Program Manager for NBC Defense. The Defense Threat Reduction Agency (DTRA) was established in 1998 as a combat support agency to address combating WMD issues. The DoD CB defense community showed little to no interest in the development of a DoD counterproliferation strategy in the late 1990s. Yet all four services, including the Army, resisted calls in 1999 to change the management structure, despite numerous criticisms and repeated failures to field new CB defense equipment on time and within budget.

The 9/11 attack was the catalyst to restructuring the DoD CBDP in 2002-2003, resulting in the creation of permanent, full-time offices within the DoD acquisition process. It also resulted in adding consequence management and installation protection as new responsibilities to the traditionally passive defense-focused program. The Under Secretary of Defense for Acquisition, Logistics and Technology (AT&L) approved an implementation plan that identified the Army as the material developer, test and evaluation executive, and program analysis and integration director of the DoD CBDP.[3] Over the last ten years, we have seen new defense strategies for combating WMD and combating terrorism, significant changes in joint and multi-service doctrine, the development of a top-down and joint "capability-based" development process, and U.S. Strategic Command's (USSTRATCOM) new role as the "synchronizer and integrator" of DoD combating WMD efforts. The stand-up of U.S. Northern Command (USNORTHCOM) initiated new discussions of homeland defense/civil support missions and capabilities, while U.S. Special Operations Command (USSOCOM) addressed WMD terrorism concerns.

Despite these new DoD strategies, priorities, and direction, the DoD CBDP has remained focused on fielding the same passive defense equipment that it developed in the 1990s. The program

traditionally favors building detectors and protective suits and masks over other CB defense capabilities, resulting in the addition of specialized, unique systems to the military force rather than integrating these capabilities into other major defense systems. The exceptions have been a small number of expensive, challenging initiatives that were directed by OSD and Congress (e.g., WMD Civil Support Teams, CB Installation Protection Program, Transformational Medical Technologies Initiative). The most recent OSD initiatives have been the "Medical Countermeasures Initiative" and global medical biosurveillance. Constant discussions about radiological and nuclear terrorism has called into question whether the DoD CBDP should address chemical, biological, radiological and nuclear (CBRN) defense capabilities that are not inherently passive defense in nature. Over the past ten years, the Army has not, however, led the DoD CBDP into these new combating WMD areas.

**The Challenges for a DoD Executive Agent**

The DoD CBDP has not evolved along with the national security strategy and its direction over the past decade. Part of the problem has been the changing nature of the combating WMD culture. The National Strategy to Combat WMD uses a counterproliferation concept to address homeland security challenges, articulating the concern that terrorists might employ WMD developed by "rogue" nation-states against the United States.[4] This was a dramatic change from pre-9/11 operational concepts and strategies addressing adversarial WMD programs and terrorism challenges. Since 2002, DoD has viewed counterproliferation, combating terrorism, and federal responses to industrial accidents and infectious disease in the context of WMD. As a result of this larger mission set, the Chemical Corps and Functional Area (FA) 52 (nuclear and counterproliferation) community have been shouldered aside for a new cast of post-9/11 "WMD experts." In response, the Army has chosen to repeat combating WMD narratives from higher strategic documents, rather than to critically examine the need for a new post-Cold War concept.

When the 1993 public law was passed in Congress, there was no question as to what "CB defense" meant – it was the protection of military forces against CB warfare agents. The combating terrorism and the homeland security communities are using the term "CBRN defense" in discussions of policy, budget, and authorities, but U.S. Code still directs DoD to use the CBDP to procure all DoD CB defense needs.[5] Because of the broadened mission, some have claimed that every piece of CBRN defense gear needs to be "dual-purpose" and applicable across the range of military operations. As a result, the desired equipment has become more expensive (due to the added requirements) and now requires more time to test and field. In addition, because the program's budget has not appreciably risen to accommodate every CBRN defense requirement across the combating WMD, combating terrorism, and homeland security missions, this has resulted in less capability fielded to the force, not more.

Many young Army officers on their first tour of duty inside the Pentagon are unprepared to deal with the DoD bureaucracy, being more familiar with field operations than staffing action packages. They often have difficulty understanding the implications of particular defense initiatives or how to engage the process in which CBRN defense issues are developed. They are outmaneuvered by those professionals who do understand the subtleties of defense policy and budgets and whose terms are longer than the two-three year tours of duty of a typical military officer. There are Chemical Corps and FA 52 officers at OSD Policy and AT&L, the Joint Staff, and offices within the DoD CBDP and Army staff, but they have not significantly impacted the direction of the program.

Currently, the DoD CBDP does not have a strategic plan, at least not in the terms of what the Government Accountability Office would call a strategic plan, one with measurable actions and discussion of available resources.[6] The DoD Annual Report to Congress on CB Defense is not a strategic plan. Every year, the DOD CBDP stakeholders meet to develop a budget strategy. Every year, the same priorities and issues emerge for debate. And every year, the same projects (despite their respective success or failure over time) are funded at essentially the same levels.[7] There is little to no formal review of the program's progress and direction to address critical capability gaps.

Despite the end of the Cold War, we remain mired in the general mindset of a passive defense construct that requires a large and technically-focused specialist force to execute the DoD's CB defense requirements. The deliberate segregation of all combating WMD tasks in the Universal Joint Task List from the rest of the military tasks and capabilities, rather than integrating CB defense into current defense concepts and policy, has been a mistake. The "WMD/CBRN" definition now includes toxic industrial chemicals, natural disease outbreaks, and radiological hazards, and yet at the same time, no one considers the costs and benefits of trying to develop CB defense equipment to address these hazards in addition to military warfare agents. The tyranny of the scientific/technological elite drives the development of CBRN defense capabilities, concepts, and even policy, rather than any critical examination of operational capability needs against overall defense roles and missions.

There are few forums in which to discuss these important issues. The Chemical School sponsors multi-service CBRN defense training and doctrine development, but it largely stays at the tactical level of discussion and within the small community of CBRN technical experts. The Joint CBRN Defense Conference,

formerly the Worldwide Chemical Conference, has not been the stage for academic or policy discussions for many years. The USSTRATCOM Global Synchronization Conference is an important forum, but it focuses more on regional plans, nonproliferation challenges, and consequence management than combating WMD policy and CBRN defense capabilities. As an example, after years of discussion, there still is no consensus on how to define foreign consequence management. The National Defense University has an annual combating WMD symposium that consistently has a number of impressive speakers. But the participants talk more about nuclear weapons and nonproliferation issues than counterproliferation or passive defense in particular.

**Redefining the DoD Executive Agent Role**

It remains unclear if the senior Army leadership (at the three-four star level and respective senior executive services) is convinced that it should proactively engage and lead the greater defense community on CBRN defense issues. If this were to take place, the Army leadership needs to understand what this engagement role would require. It has to be more than just fielding full-time specialist units and writing operational doctrine for the Army. This mission statement is offered as a starting point: *The Army, as the DoD Executive Agent for CB Defense, coordinates and integrates the RDT&E and acquisition requirements of the military departments for CBRN defense capabilities within combating WMD, combating terrorism, and homeland security efforts*. This includes:

- Advocating military CBRN defense capabilities for all Services and combatant commands in line with national defense strategy and defense policy direction

- Leading the development of DoD CBRN defense issues based on analytically-derived facts and using rational cost/benefit projections of the consequences of action or inaction

- Supporting interagency and international discussions on DoD CBRN defense capabilities in support of military combat operations, as well as combating terrorism and homeland security

- Identifying critical DoD CBRN defense capability shortfalls, assessing the status of RDT&E projects, and leading the planning, programming, budgeting and executing of the DoD CBDP

- Supporting the operations and sustainment of critical Army CBRN defense RDT&E infrastructure with Army funds and personnel

- Developing professionals who understand the complexities of DoD CBRN defense and who are engaged with the broader defense community on critical DoD counter-WMD issues

Specific actions to execute this mission should include the following.

Update the DoD directive on management of the DOD CBDP. The original DoDD 5160.5 was signed in 1985 and addressed the development of chemical weapons in addition to CB defense.[8] It should have been updated in 2000, but (as noted previously) the DoD CB defense community had no desire for change and OSD did not push the issue. The AT&L signed an implementation plan to restructure the DoD CBDP in 2003, but it took until 2008 to update the DoDD with those roles and responsibilities (perhaps waiting for the completion of DoDD 2060.2, *DoD Combating WMD Policy*, signed in 2007).[9] However, the current directive did not really change the way that DoD addressed RDT&E and acquisition of CB defense equipment. It does not reflect that the term "CBRN defense" has fundamentally changed, and yet the way DoD develops and acquires CBRN defense equipment has not changed.

The definition of what a WMD is and what CBRN defense entails remains unclear, not only within DoD but across the interagency. Despite significant capability gaps within passive defense, the DoD CBDP is trying to address select capability gaps within antiterrorism, consequence management, WMD elimination and interdiction, medical biosurveillance, and medical countermeasures for infectious diseases other than validated biological warfare threats. Now when the DoD budget was flush, it was easy for the CBDP to research and develop equipment for purposes other than passive defense, but those days are long gone. The current budget will not allow for all critical CBRN defense requirements to be funded. If the Army does not clearly define what CBRN defense is and is not, and what the CBDP should and should not address, it will be defined by others. And the result will not be favorable for the Army or other Services.

Establish an advocacy at senior levels within HQDA, OSD, USSTRATCOM, and Congress. Countering WMD threats is not a top priority for DoD, let alone the U.S. government, despite heavy rhetorical language to the contrary. Yes, the term "WMD" is mentioned in certain strategy documents. Yes, there are advocates for counter-WMD and CBRN defense issues within HQDA, OSD, and USSTRATCOM. Yes, there is a Joint Senior Leaders Course at Fort Leonard-Wood. These facts have not resulted in the successful resolution of counter-WMD issues within the larger DoD/US Government. All too often when WMD is brought up, whether in a wargame or during a crisis, the topic is segregated from "normal" defense issues as a distinct strategic concern to be addressed by "someone else." Without the support of Army leaders above the two-star level, it becomes very challenging to ensure that the desired outcome of any policy discussion will be reflective of Service concerns. At the same time, the Chemical Corps and FA52 community must

understand the greater scope of defense priorities and concerns.

Working with the defense community within Washington DC is vital to developing a long-term constituency. This cannot be done from Fort Leonard-Wood or Offutt Air Force Base. OSD leaders will support the Army's Executive Agent role only if they see some value-added in the discussion of counter-WMD issues in light of other, more urgent defense priorities of the day. There are many, many other defense issues and larger acquisition programs that command the attention of defense leaders. The DoD CBDP budget is less than one-half of one percent of the DoD budget, and as long as there is no immediate crisis involving WMD, there will be other meetings, other issues viewed as more deserving of time and funds.[10] The Army must be able to articulate why OSD should address CBRN defense issues within the overall scope of contemporary defense policy.

Within the Joint Staff, "combating WMD" responsibilities are split between four offices (J3, J4, J5, and J8). There are many priorities, few staff, and little time to adequately develop the issues. The combatant commands have many concerns, but CBRN defense is often not a priority (again, except in time of crisis). As a result of the staffing process, any Joint Staff action can result in a product developed by census, and thus may lack clarity and focus. If the Army does not have strong ties with these offices or is not engaged with the Joint Staff on the development of CBRN defense capabilities, it is losing ground. On rare occasions, the Joint Staff might work a WMD issue raised by a combatant command or an OSD office, but if that happens without Army participation, the outcome may not be favorable.

Last, Congress is the Army's friend. Every legislative representative wants to see the Army remain strong, but sometimes the Army has difficulty in effectively communicating its message. Of course, the Army cannot lobby Congress on specific defense issues that are to be legislated. That doesn't mean that the Army cannot inform Congress about its CBRN defense capabilities and concerns through appropriate channels. Recently, in response to OSD direction to reduce the number and length of annual reports to Congress, the DoD Annual Report to Congress on CB Defense was changed from a colorful, informative discussion to a very short, black-and-white report that barely addressed the legal requirements of 50 USC 1522.[11] This decision was a significant failure of strategic communications and needs to be rethought.

Redefine and strengthen the CBDP research and development program. The CBDP is executing the same R&D program that existed since the 1980s – "avoid, protect, and decon, in that order!" It continues to promote the stove-piped development of specialized CB defense gear that the warfighter often sees as unnecessary or burdensome during both conventional and irregular conflicts. To be successful, the DoD CBDP needs to integrate CB defense equipment into existing major defense acquisition programs rather than develop stand-alone equipment that might be integrated into other defense systems after the thought. A few years back, a project manager under Army PEO Soldier decided to abandon an integrated helmet-protective mask concept for its next generation land warrior program. There is little, if any, agreement on how to develop the next generation protective suit, other than it will be a separate suit, not integrated, into the future soldier system. There was no plan to integrate CBRN defense capabilities into the Future Combat System vehicles other than to plug in currently existing chemical and radiological detectors.

The U.S. military has the most sophisticated reconnaissance, detection, and identification equipment in the world, and in an effort to achieve the Star Trek tricorder standard, continues to throw millions of dollars after immature technologies and unreachable requirements. It is unlikely that the DoD CBDP can develop any protective mask or suit with significantly improved capabilities over what has been fielded to date. But there is no attempt to integrate collective protection into fixed buildings, military vehicles, or military shelters. There is very little funding for a new decontaminant, which retards the ability to effectively decon military systems or to ensure fixed sites can recover from a CBRN attack. There is no attempt to address CBRN contamination survivability requirements for DoD major defense acquisition programs. As OSD redefines the term "WMD" to include natural infectious diseases, the ability to develop new CBRN defense capabilities for the military is diminished.[12]

Redefine and strengthen the CBDP acquisition program. Until there are adequate funds to execute a CBRN defense program that addresses all combating WMD, combating terrorism, and homeland security requirements, military forces will lack critical passive defense capabilities. Given funding realities and existing threats, the DoD CBDP needs to carefully procure the right equipment and capabilities for the force. One step would be to stop procuring consumable CB defense items such as protective suits and medical chemical countermeasures for the services. The counterargument has been the services won't use operations and sustainment funds to buy consumable CB defense equipment, so the industrial base will suffer. This is a flawed argument. The Services have a Title 10 responsibility to sustain their operational capabilities in the field. If they shirk these responsibilities, they need to be held accountable.[13]

*It is not the CBDP responsibility to buy all the CBRN defense equipment for all the Services' requirements*. This statement is hard for some to understand. Antiterrorism/force protection is a Service and combatant command responsibility, and the Services should be free to procure CBRN defense equipment within the context of their antiterrorism priorities. Homeland security

requires other government agencies to procure CBRN defense capabilities that can be sustained for responses to domestic incidents. The medical community has the responsibility to develop and procure capabilities for force health protection, to include protection against military warfare agents. While the medical response to CBRN weapons and industrial chemicals, natural diseases, and radiological accidents may be similar, that should not be an excuse to mandate that the CBDP fund the development of all material solutions to CBRN hazards. The DOD CBDP needs a true six-year strategic plan, with clear mission, vision, and goals and measurable actions, and someone who will hold feet to the fire to accomplish those actions.

Redefine and strengthen the CBDP test and evaluation program. Although the four Services all have independent test and evaluation (T&E) agencies, there is only one Service that has the expertise and infrastructure to execute developmental and operational T&E of CBRN defense equipment. The CBDP coordinates the four Services' T&E efforts under an Army office, but the cost of modernizing and sustaining that T&E capability is considerable. Prior to the 2003 reorganization, the Army was using its own funds to pay for its T&E facilities, and as a result, there were significant slips in program schedules and high customer costs to the program. As a result of the reorganization, the DoD CBDP moved hundreds of millions of dollars into the Army's T&E infrastructure (notably, Dugway Proving Ground and Edgewood CB Center). However, sustaining and modernizing that capability continues to demand a high price, especially as the program attempts to address future threats and natural diseases.

Maintaining the funding for Army T&E facilities is an ongoing struggle during the annual budget builds. To some people, any CBDP money going to T&E is less money for research or fielding equipment. The Army as a whole (not just the Army T&E office) needs to justify what the DoD CBDP should fund, as opposed to what is funded by Army money. In addition, OSD decided to fund some Army laboratory modernization efforts that are related to CB defense research. This second effort is less well-justified, and should be terminated. The Army should demonstrate the cost/benefits of its T&E capabilities, while showing its willingness to use its own operating funds to ensure that basic laboratory capability at Edgewood, at Fort Detrick, and at Dugway continues in the future.

Educate the Army's rank and file. The Air Force War College hosts the Air Force Counterproliferation Center, which runs elective WMD classes for Air Force students, hosts an annual conference on counterproliferation, and releases publications on relevant and current topics.[14] Where is the Army's equivalent? Although there have been advances in joint professional military education, most students attending the Army War College and advanced schools at Fort Leavenworth probably do not learn about WMD issues and CBRN defense. Perusing the Army's Strategic Studies Institute web site demonstrates two things – the high quality of academic papers being researched and published, and the absolute lack of any discussion on combating WMD. If combating WMD is one of the DOD's top future priorities, where is the education and discussion going on within the Army?

The Army may have a combating WMD concept, but outside of the CBRN defense community, discussion of WMD issues within the context of other Army doctrine and concepts isn't happening. Developing a combating WMD elective at Carlisle and Leavenworth may require time and funds that the CBRN School (or DTRA) doesn't have. This goes back to the advocacy issue – as the DoD Executive Agent for CB defense, the Army needs to be seen as the thought leaders for CBRN defense. That means investing in joint professional military education, both formally through the senior warfighting schools and through a broader publication basis.

Initiate an aggressive engagement strategy within the Army. There are only a few publications that promote CBRN defense discussions, notably the Army's *Chemical Review* and the USANCA *Combating WMD Journal*. Recently, both magazines have gone to electronic formats, a step that was both long overdue and beneficial to increasing the discussion of WMD-related issues. Given the broad scope of topics and issues in the field, one might hope for quarterly distribution of both magazines, but there are known financial limitations. In addition, the Joint Program Executive Office for CB Defense has a quarterly journal and other information products that discuss its research, development, and acquisition efforts.[15] These are good publications and need to be fully supported.

However, there isn't much evidence of the Army taking advantage of all of the evolving information technology efforts that have so significantly reduced communication barriers across the world. There are no electronic forum and few web sites that promote the discussion of WMD issues. One might point to various small discussion groups within select forums, and perhaps there are discussions within Army Knowledge Online, but these forums are limited and closed to the larger combating WMD community. We need to include industry and academia in the discussion to cross-fertilize the Army doctrine and concepts with new ideas. Not all good ideas originate within the military. If industry is there to get some valuable insights to developing new widgets, isn't that still a good end result?

The Chemical Corps Regimental Association (CCRA) needs to evolve from its current status of focusing on history and embrace modern business strategies that increase its visibility. The CCRA needs to leverage the active and retired Army community to advocate Chemical Corps challenges and needs with the public, with Congress, and with industry. The Association of the United States Army is a good model, and the CCRA needs to learn some best

practices from it. The Army could do worse than to move the Joint CBRN Defense Conference to Washington DC and to promote more diverse speakers other than the usual suspects from the DoD CBDP, bringing out the usual information briefs.

**Conclusions**

The DoD CBDP has fundamentally failed to evolve with the changes in national security over the past decade. A primary challenge is the lack of interest in CBRN defense issues above the two-star general officer level within Washington DC. The Army needs to demonstrate the acumen and leadership that propelled the Chemical Corps from near-extinction in 1973 to becoming a relevant combat support force in 1990. If the Army leads the way with its very talented community of CBRN defense and combating WMD experts, the other Services and the OSD offices will follow. It is because of the lapse of vision, the inability to articulate critical issues and advocate for new capabilities across all the services and defense agencies, that they have lost faith. It's time for a new direction, one that recognizes the future national security trends and that integrates new concepts that are defendable and executable.

In 2000, Stephen Scroggs penned a book titled "Army Relations with Congress: Thick Armor, Dull Sword, Slow Horse."[16] He described Army leadership as deeply committed to national security and willing to do more with less, if the budget didn't fund everything that they desired. However, there were characteristics that prevented the Army from being fully successful. These included insufficiently engaging its members on top priorities in advance of budget cycles; being reactive to critical national security issues instead of proactively planning for potential crises; treating OSD and Congressional interaction as a burden rather than an opportunity; and having the tendency to be inwardly focused and risk adverse.

The Army Chemical Corps and FA52 community mirror these characteristics as well. This shouldn't be a surprise; it's natural for subordinate elements to mirror their leadership. However, these are detriments to executing the "DoD Executive Agent" role and joint engagement on combating WMD issues. The legislation that created the DoD CBDP and a DoD Executive Agent role can be changed to allow DTRA to lead or to devolve the program back to the four Services. Given the Army's significant investment in this area, that path should be avoided, but that requires the Army's combating WMD community to aggressively lead the DoD toward the development of new strategies, new operational concepts, and new capabilities that are sustainable and executable in the future joint operational environment.

**Author Biographical**

*Al Mauroni is a senior policy analyst with more than 25 years in the area of DoD chemical-biological warfare and defense programs and policy. He is a former Army officer and 1985 graduate of Carnegie-Mellon University. He has published six books, the latest of which is "Where Are The WMDs?" by the Naval Institute Press, and has also published numerous journal articles on the topic. The views expressed in this article are my own, and do not necessarily represent the views of the Department of Defense or any other office.*

**End Notes**


1. National Defense Authorization Act for Fiscal Year 1994, dated 18 Nov 93, 50 USC 1522.

2. DoD Report to Congress, "Domestic Preparedness Program in the Defense Against Weapons of Mass Destruction, " dated 1 May 97, http://www.dod.mil/pubs/domestic/.

3. USD(AT&L) Memorandum, subject: "Implementation Plan for the Management of the Chemical Biological Defense Program," dated 22 Apr 03.

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5. http://www.law.cornell.edu/uscode/text/50/1522).

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8. Al Mauroni, Where Are the WMDs? The Reality of Chem-Bio Threats on the Home Front and the Battlefield (Annapolis, MD: Naval Institute Press, 2006), p. 28.

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11. 2011 DoD Annual Report to Congress on Chemical and Biological Warfare Defense http://www.acq.osd.mil/cp/docs/2011_CBDP_ARC_V26_FINAL.pdf) with any one of the reports done prior to 2011.

12. 2011 DoD Annual Report to Congress (Ibid), p. 4, narrative on the Transformational Medical Technologies project.

13. 32 US Code section 368.6, "Functions of the Military Departments," http://www.gpo.gov/fdsys/pkg/CFR-2002-title32-vol2/xml/CFR-2002-title32-vol2-sec368-6.xml.

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# Fort Belvoir Nuclear Revisited in April 2011

Julia LeDoux
Special contributor to the Belvoir Eagle

Mr. Phil Shubert,
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Fort Belvoir Army Reactor

Fort Belvoir Army Reactor Plaque

Former Army Reactor Program graduates Malcolm McLeod and Emery Chase recently revisited Fort Belvoir's long- deactivated nuclear power plant, which the U. S. Army Corps of Engineers is decommissioning.

In addition to planning and leading the decommissioning effort, the United States Army Corps of Engineers has been tasked with maintaining the plant, its security and safety and is actively engaged in maintaining both the facility and the health and safety of the public, since its deactivation,' said McLeod, who now works with the USACE and received his nuclear power plant operator training at Belvoir.

The 2- megawatt plant - designated as SM- 1 - went online in 1957 and was deactivated in 1977. When the plant was deactivated, both its fuel and control rods were removed, said McLeod, who added that any remaining radiation at the facility is essentially embedded, meaning the facility is not like an active nuclear plant and presents no hazards to the public's health and safety.

The plant provided the installation's electrical power and served as the training site for the Army Nuclear Power Program, which operated eight plants around the world.

"It's a profession. The people that went into this who are in it today in the commercial world do a superb job," said Chase, a former nuclear power plant operator for the Army who trained at Belvoir in 1969.

It was also the first nuclear power station to be connected to an electrical grid, said Phil Shubert, Army Reactor Program Manager.

"It was not a major source of power, because it was mainly supplying the Fort, but it did tie into the grid," said Shubert, a licensed senior reactor operator who trained with the Tennessee Valley Authority. "The Fort Belvoir's reactor's main purpose was to train personnel in how to operate a plant, in addition to providing power for the base." An agreement between the then Atomic Energy Commission and the Department of Defense led to the program's creation and the plants' construction.

"They were looking at nuclear technology both for weapons and power," explained Shubert.

There is no nuclear fuel at the plant, continued Shubert, who said the decommissioning process is arduous.

"You have to make sure there are no hazards present," he explained. "You have to survey for a number of things. In the time frame it was built, there will be some issues, like asbestos." The plant is at the southeast boundary of the post and overlooks Gunston Cove. Migrating

Ospreys Nest on stack

ospreys love the area, Shubert said, and there is an osprey nest at the top of its stack. “It’s a beautiful spot,” he added.

Chase had a master’s degree and was a captain in the Army when he was accepted into the program, which included academic and the hands- on operation of the plant.

“I pulled shifts,” he said. “That was true of both officers and enlisted (personnel).” The Fort Belvoir plant operated 24/7 and had a staff of 55.

“It was never left by itself,” Chase said. “You did all your own maintenance.” Shubert said, the operators also had to maintain their qualifications and were nearly always training.

“We produced a cadre of operators and engineers that safely operated these plants for decades,” he added.

Chase was stationed in Panama after he graduated from the program. While there, he initially worked in a conventional power plant before becoming executive officer aboard the MH- 1 Sturgis, which pulled its first critical, a condition operators use to describe the status of the nuclear fission process, at Belvoir. The Sturgis was towed to Panama and moored at Lake Gatun, where it provided 10 megawatts of electrical power.

An interior shot of Fort Belvoir’s deactivated nuclear power plant.

Shubert said the decommissioning of the SM- 1 could take some time, but, when the effort is completed, it should free up some additional space for the installation.

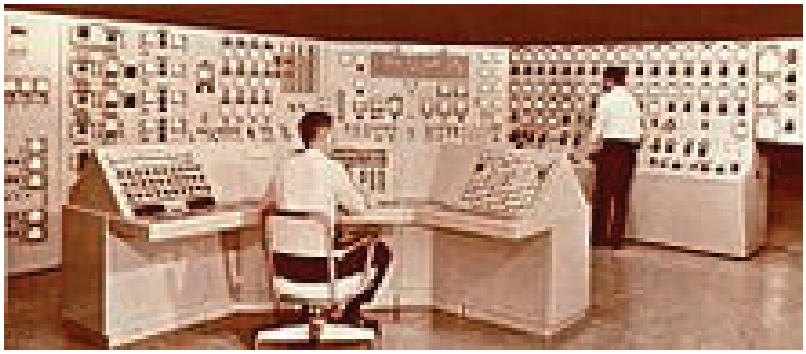
Additional information on the Army Nuclear Power Program

• SM-1: 2 MWe. Fort Belvoir, VA, Initial criticality April 8, 1957 and the first U.S. nuclear power plant to be connected to a commercial electrical grid. Used primarily for training and testing, rather than power generation for Ft. Belvoir. The plant was designed by the American Locomotive Company and was the first reactor developed under the Army Nuclear Power Program.

• SL-1: Boiling water reactor (BWR), 300 kWe, National Reactor Testing Station, Idaho. Initial criticality August 11, 1958. Site of the only fatal accident at a US nuclear power reactor, on January 3, 1961, which destroyed the reactor. The SL-1 was designed by the Argonne National Laboratory to gain experience in boiling water reactor operations, develop performance characteristics, train military crews, and test components. Combustion Engineering was awarded a contract by the AEC to operate the SL-1 and in turn employed the Army’s military operating crew to continue running the plant. This BWR was specifically designed to power Distance Early Warning (DEW) line stations.

• PM-2A: 2 MWe, plus heating. Camp Century, Greenland. Initial criticality October 3, 1960. The first “portable” nuclear power reactor. Brought to Greenland in parts, assembled, operated, disassembled, shipped back to CONUS.[5] The PM-2A in Camp Century, Greenland, was designed by the American Locomotive Company to demonstrate the ability to assemble a nuclear power plant from prefabricated components in a remote, arctic location. The pressure vessel was subsequently used to investigate neutron embrittlement in carbon steel. This plant was shut down 1963-1964. PM-2A operated at a uranium-235 enrichment of 93 percent.

• ML-1: first closed cycle gas turbine. Initial criticality was on March 30, 1961. Designed for 300 kWe, but only achieved 140 kWe. Operated for only a few hundred hours of testing. The ML-1 was designed by Aerojet General Corporation to test an integrated reactor package that was transportable by military semi-trailers, railroad flatcars, and barges. This reactor was shut down in 1965.



MH-1A control room simulator

• PM-1: 1.25 MWe, plus heating. Sundance, Wyoming. Owned by the Air Force, this pressurized water reactor was used to power a radar station. Initial criticality was on February 25, 1962. The PM-1 was designed by the Martin Company and provided electric power to the 731st Radar Squadron of the North American Air Defense Command (NORAD). This plant was shut down in 1968. PM-1 operated at a uranium-235 enrichment of 93 percent.

• PM-3A: 1.75 MWe, plus heating and desalinization. McMurdo Station, Antarctica.[8] Owned by the Navy. Initial criticality March 3, 1962, decommissioned 1972. The PM-3A, located at McMurdo Sound, Antarctica, was designed by the Martin Company to provide electric power and steam heating to the Naval Air Facility at McMurdo Sound. PM-3A operated at an uranium-235 enrichment of 93 percent.

• SM-1A: 2 MWe, plus heating. Fort Greely, Alaska. Initial criticality March 13, 1962. The SM-1A at Ft. Greely, Alaska, was designed by the American Locomotive Company and was the first field facility developed under the Army Nuclear Power Program. This site was selected to develop construction methods in a remote, arctic location. This plant was shut down in 1972. SM-1A operated at a uranium-235 enrichment of 93 percent.

• MH-1A: Power production10 MWe, Mounted on the Sturgis, a barge (no propulsion systems) converted from a Liberty ship, and moored in the Panama Canal Zone. Initial criticality at Ft. Belvoir, VA (in Gunston Cove, off the Potomac River), January 24, 1967. It was the last of the eight plants to permanently cease operation. The MH-1A was designed by Martin Marietta Corporation. It remained moored at Gatun Lake in the Panama Canal from 1968 until 1977, when it was towed back to Ft. Belvoir for decommissioning. It was moved to the James River Reserve Fleet in 1978 for an expected 50 years of safe storage. This reactor used low-enrichment uranium (LEU) in the range of 4 to 7 percent. The MH-1A had an elaborate analog-computer-powered simulator installed at the Training Division, USAERG, Ft. Belvoir.

• Final Notes: The Army Reactor Office located at Fort Belvoir and residing in the US Army Nuclear and Combating Weapons of Mass Destruction Agency administers the program for permitting operation and decommissioning of the Army's Nuclear reactors.

• The Corps of Engineers' Radiation Safety Officer Maureen Zeiner was coordinator for the visit to SM-1. Thanks from the Army Reactor Office is extended to her.

**Author Biographical**

*Julia LeDoux is military editor of the News & Messenger. She joined the newspaper in 2005 as a staff reporter for the Belvoir Eagle and was named military editor in 2007. Previously she worked at the Outer Banks Sentinel, Topsail Voice and WLAS-AM in North Carolina before moving to Virginia in 2005. A graduate of the University of North Carolina at Wilmington*

*Mr. Phil Shubert currently heads the Army's Reactor Office. He is a Mechanical Engineering graduate from the University of Tennessee and served in the Navy as a Naval Flight Officer, with over 200 carrier landings on the USS Forrestal. He later served as a Senior Reactor Operator for the Tennessee Valley Authority (TVA), where he supervised the loading of the first fuel assembly at Watts Bar and was Unit Operating Supervisor for the initial critical for Watts Bar in 1996. From 1997-2007 he served with the Joint Warfare Analysis Center (JWAC), a joint command located at Dahlgren Naval Base. From 2007-2011, he was a US manager for Alstom, which is a French multinational conglomerate. Phil returned to US government service in 2011 as the Army Reactor Program manager under the US Army Nuclear and Combating WMD Agency (USANCA).*

# Heisenberg In Action--A year plus in the life of the Nuclear Disablement Teams

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The Nuclear Disablement Teams (NDT) of the 20th Support Command (SUPCOM) maintain a demanding training regimen in order to ensure mission readiness. The NDTs have a primary mission of assessing and disabling nuclear weapons production infrastructure, a strategic mission focused on actors and countries of proliferation concern. The teams have a secondary task of supporting the National Technical Nuclear Forensics (NTNF) Ground Sampling Mission (GSM) where an NDT, along with several enablers, operates as part of an FBI-led Inter-Agency Task Force to collect samples in a post nuclear detonation environment. Both mission areas require planning and training focus in order to be prepared on very short notice to execute.

The 2010 Quadrennial Defense Review (QDR) called for an increase in Nuclear Disablement capability. Subsequently, the Army and the 20th SUPCOM have added a third NDT in FY11, with a fourth to be added in FY12. Because of the unique nature of the disablement mission, standard field type training at Army installations is not feasible. The NDTs require specialized support from Department of Energy (DOE) Laboratories, to include access to their infrastructure and facilities, subject matter expertise on nuclear fuel cycle as well as material production and handling. In addition, DOE provides radiation sources that can provide a realistic signal to the various detection equipment and software the NDTs use to conduct their mission.

Throughout calendar year 2010 and into 2011, NDTs 1 & 2 were engaged in multiple training events and exercises, developing and honing skills for both the Disablement and NTNF mission sets. For the first part of the year, NDT 1 remained focused on supporting the disablement mission- the part of the team went to Korea to support Exercise Key Resolve. NDT 2 began the transition of the NTNF mission from DTRA's Washington Technical Support Group (WTSG). In April, both teams then spent two and a half weeks at Idaho National Lab for the pilot Nuclear Infrastructure, Assessment and Disablement Course (NIAD). NIAD is an annual disablement training course designed to train NDT personnel as well as those involved in WMD Elimination intelligence analysis and operational planning.

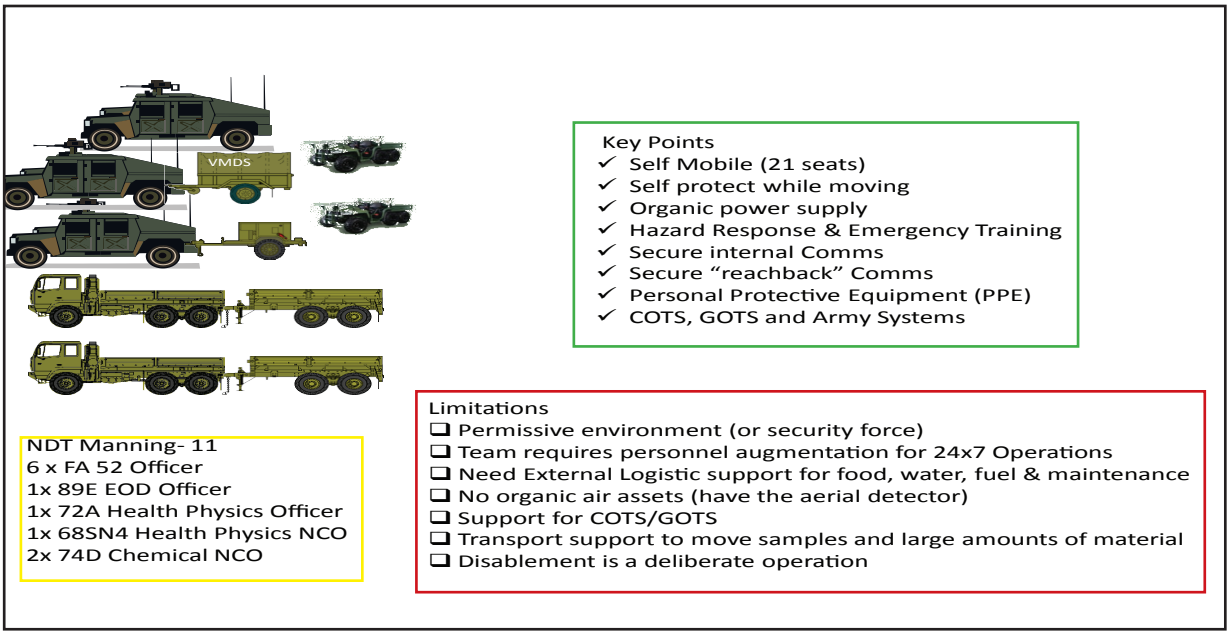
In May 2010, NDT 2 took the lead for Exercise Shining Tortoise, a full inter-agency (FBI & DoE) NTNF exercise at Nevada Test Site. The summer was spent in finalizing the transition of NTNF equipment from WTSG and planning for the 20th SUPCOM Exercise Liberty Focus at Ft. Hood, TX. In August, NDT2 assumed the NTNF mission from WTSG and concurrently prepared for Exercise Liberty Focus. Liberty Focus is the 20th SUPCOM Annual WMD Elimination exercise, where the command exercises its Joint Task Force HQ capability. In a first for the command, the NDTs conducted tactical disablement training at Ft. Hood, and integrated exploitation information into the simulation part of the exercise. Finally, in November the NDT 1 conducted a validation exercise at Ft. Dix, NJ in order to refine skills to assume the NTNF mission from NDT 2. In all, a fast year for the Nuclear Disablement Teams of the 20th SUPCOM. The paragraphs below provide an overview of the NDT and outline the major training events the teams have been involved with.

**Nuclear Disablement Team**

The NDT is an 11 man team of technical experts, with a strategic mission to assess, exploit and disable nuclear weapons production infrastructure. In addition, the NDTs provide the core of the Army's National Technical Nuclear Forensics (NTNF) Ground Sampling Mission capability. The team has a combination of Army equipment that provides the teams mobility, communications and protection; and commercial-off-the-shelf (COTS) equipment that provides the team the bulk of its radiation/nuclear detection and analysis equipment. In addition, the team uses both Army and COTS personal protective equipment to ensure team members can operate safely in unique hazardous environments.

Ultimately, the strength of the team is in the knowledge and skill of the personnel- the various skill sets: FA 52s with a broad knowledge base in nuclear weapons design, nuclear fuel cycle, nuclear physics and nuclear plans and policy along with health physicists' understanding of the physiological effects of radiation on humans; Explosive ordnance knowledge in identifying and mitigating other hazards to team operations; and finally the chemical specialists capability in initial entry operations and material sampling, packaging and transport. These talents combined together give the NDT a distinctive strategic capability for the Army that is unmatched.

The NDTs also possess a unique set of equipment known as STIRS (Smart Threads Integrated Radiological Sensors) which provides a networked set of radiation detection capabilities. STIRS detectors include ARDIMS (Aerial Radiation Detection and Mapping System), VMDS and VMDS-L (Vehicle Mounted Detection System and Vehicle




Nuclear Disablement Teams

Mounted Detection System-Lite) and MPDS (Man Portable Detection System. The STIRS network uses a self-healing, mesh network of radios to transmit data from the various sensors to the NDT command post, where the data is collated, interpreted and analyzed with the help of MFK-R (Mobile Field Kit – Radiological) software and Peak-Easy spectrum analysis software. The NDT utilizes sub-teams, outlined below, to execute its disablement missions:

- Initial Entry Team

The Initial Entry Team (IET) conducts site reconnaissance, identifies hazards, and gains access to the target. The team utilizes a number of tools including: radiation and chemical detectors, air monitors, and breech and access tools. The team consists of a Team Leader (FA 52), an Initial Entry NCO (MOS 74DL3 – CBRNE NCO) and when the NDT is augmented, Explosive Ordinance Disposal (EOD) personnel.

- Contamination Control/Hotline Team

The hotline team monitors personnel and equipment and limits the spread of radiological material and other potential contamination. In addition to contamination control, the Hotline Team also advises on individual exposure guidance, tracks individual total accumulated dose, and physiologically monitors all team members. The team consists of a Health Physicist Officer (72A), and a Health Physicist NCO (68SN4).

- Command Post

The command post monitors all operations in real time via FM, SATCOM, and a networked computer system using Mobile Field Kit-Radiation. The Command Post consolidates information, sketches, photographs and spectrum, from the objective for an onsite review and then forwards information to a designated headquarters or intelligence analysis center. The command post team consists of an Operations Officer FA 52, and 2-3 communications Soldiers MOS 25 B/U/S. In addition, the NDT Chief spends time in the CP assisting the Operations officer with communication to higher as well as reviewing collected data and information.

- Characterization and Disablement

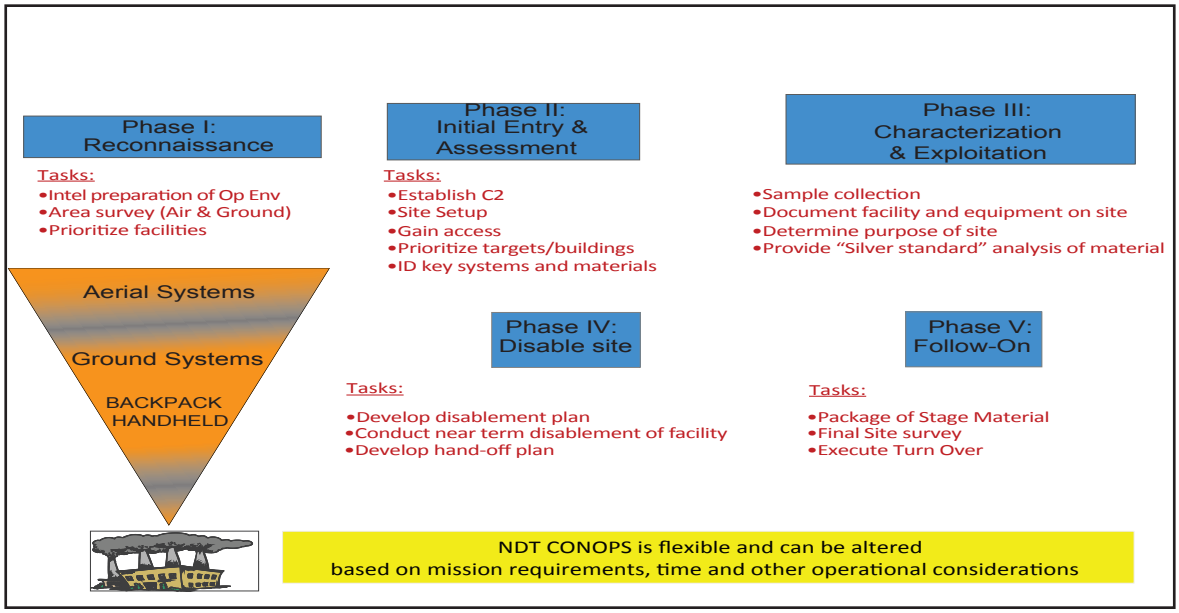
The Characterization Team conducts the sensitive site exploitation of the target building; in reality this will involve all of the NDT members and in many cases other enablers such as intelligence analysts and engineers. Using detectors, STIRS, MFK-R, and other laboratory tools, the Characterization Team will assess the progress within the context of the nuclear fuel cycle process, and the extent of that progress. Upon completion of characterization the Disablement Phase is planned. In many cases Disablement may involve restricting access to a facility, preventing near-term repair, and rendering inoperable specific parts of the facility or related infrastructure. In addition, securing SNM and sensitive equipment and planning for retrograde of that material and equipment to a CONUS facility for in-depth analysis.

**Nuclear Disablement team Training and Exercises**

Exercise Nougat Poplar at Y-12 JAN 2010- Exercise Nougat Poplar allowed NDT 2 to develop baseline assessment and disablement skills. This exercise was a Full Operational Capability (FOC) culminating event- ensuring the team was fully capable of executing disablement operations. This exercise also incorporated several communications assets from HHC, 20th SUPCOM augmenting the team command post.

The Nougat Poplar scenario involved a single target focused on uranium enrichment and material transport. The team had to use all of its detection equipment to find suspect target sites, gain access to facilities, identify masking material and strategic nuclear material, and determine the level of enrichment of the process. In addition, the team had to package and prepare containers to ship the material as well as meet the various procedural gates to transport SNM.

**Nuclear Infrastructure and Disablement Course (NIAD) -** In October 2008, the 20th Support Command called for the development of a Nuclear Facilities Disablement Course in order to assist in the exploitation and disablement mission. The intent




NDT CONOPS

for the course was to capitalize on the knowledge base inherent to each of the DOE laboratories, specifically Idaho, Los Alamos, Sandia and Lawrence Livermore. The final version of the course, called the Nuclear Infrastructure, Assessment and Disablement (NIAD) course, was developed by Idaho National Laboratory and first run as a pilot in April-May, 2010. Based on the success of that pilot the course has now become an annual course taught at INL.

The course consists of a series of 21 modules including: tabletop exercises, field exercises and site and facility tours. The modules cover the nuclear fuel cycle, criticality, PeakEasy software calculations and spectra, fuel fabrication, reactor operations and plutonium production, reactor disablement and component recognition, reactor simulator take down exercise, weapons development and components, Counterproliferation Analysis and Planning System (CAPS) overview, fuel processing, and aqueous fuel processing tabletop exercise. In addition to this, INL has constructed a series of props that are use to create realistic, working target scenarios.

Exercise Shining Tortoise- This was a full-scale National Technical Nuclear Forensics Ground Sample Mission (NTNF GSM) Exercise, and included robust participation from the Federal Bureau of Investigation and Department of Energy. The Exercise was held at the Nevada Test Site 19 - 24 May 2010 and sample collections were conducted in and around the Johnny Boy shot crater. NDT 2 and DTRA WTSG had done an extensive NTNF training work-up to learn all about NTNF and the skills needed to execute successfully. Even so, NDT 2 worked closely with DTRA WTSG in a "left-seat, right-seat ride" method to ensure success during a major exercise.

In the event, Shining Tortoise provided NDT 2 a unique insight in to what an interagency task force looks like on the ground and more importantly, how it operates. The NDT and DTRA WTSG personnel worked closely with the DOE technical team and FBI Hazardous Material Operations Unit specialists on sample collection mission planning, mission command, control and communications and contamination control measures. One of several challenges during the exercise was having the collection teams operate over extended distances from the NTNF Task Force Forward Operating base, in some cases over 20 miles away. This distance challenges mission planners to ensure communication planning support operations as well as developing executable contamination control procedures.

Even with the challenges of the various inter-agency partners coming together for the first time, the exercise was a great success. The relationships built during the exercise and the knowledge gained by deconflicitng each agencies' procedures and process, has ensured the entire NTNF GSM Task Force is able to execute the mission today. Clearly, NTNF is a new mission area for the

NDT member in Level A suits assess a hot cell during a NIAD exercise.[1]

Army, and not all the requirements and intangibles are fully identified. The NDTs rotate on to this mission in 4-6 months cycles, along with continual interaction with the FBI and DOE partners to ensure TTP/SOP as well as alert procedures are updated and refined based on operational experience.

Liberty Focus- Nuclear Disablement Teams operations require high level proficiency on several nuclear and chemical processes involved in the production of fissile material and weapons related components. Exercise Liberty Focus 11 (LF-11), held at Ft, Hood TX 17-21 OCT 2010 enabled the NDTs to test proficiency in all phases of NDT operations and allowed a focus on nuclear engineering, radiochemistry, material sampling and shipping procedures. The NDTs utilized the Ft. Hood Underground Training Facility, a former nuclear weapons storage complex near Ft. Hood's Robert Gray Army Airfield. Developing a rigorous exercise construct that supported both the NDT tactical field training as well as supported the integration of the NDTs into the command post simulation part of the exercise was also a challenge. In addition, developing suitable targets that could be constructed in the tunnel complex at Ft. Hood tested the skills of DOE experts from Idaho National Lab, Oak Ridge National Lab and Y-12 National Security Complex.

In conjunction with NDT leadership, the DOE lab team reviewed the training concept and assured the physics and chemistry aspects of the training followed proper radiochemistry reprocessing process logic. In other words, the DOE team wanted to ensure that what they set up in the tunnels was accurate both in terms of "look and feel" and also scientifically accurate as to how a process was laid out. This included making sure the chemistry equations found on white boards and in other media were what could be expected from a pilot program of a proliferant country. DOE also deployed several chemistry challenges that stressed each teams' sampling and ID capabilities. We benefitted from their professional assistance at every stage of the planning and execution phases.

Supporting LF-11 also presented challenges never before experienced by the NDTs. For the first time NDTs operated as part of a task force which required intense coordination for logistics and personnel support. NDTs integrated during the early stages of the exercise with 23d Chemical Battalion and jointly exploited multiple targets. We coordinated for all classes of supply through our higher headquarters; this validated the NDTs support concept. Furthermore, movement and maneuver had to be closely de-conflicted to avoid training area constraints. The exercise lessons learn will guide future operations and allow the NDTs to further refine our TTPs.

In the event, the NDTs faced two target tunnels. One tunnel housed a uranium enrichment process and the other housed a separation and reprocessing facility. There was also bulk chemical storage, and receiving/shipping room involved in the scenario. In each target tunnel, the DoE team had constructed realistic lab and pilot scale process to include operating mixer-settlers, glove boxes and hot cells. Of course, DOE also provided a variety of radioactive sources to ensure that detection equipment would alarm or detect appropriately. In all Liberty Focus held a number of firsts for the NDTs to include: first tactical exercise as part of Liberty Focus, first non-simulation task organization as part of another unit, and first time NDTs have had to work the various aspects of sustainment and support.

TEEX Collapse Rescue Operations- In early January 2011, NDT 2 & 3 travelled to College Station, Texas to train at the Texas Engineering Extension or TEEX. TEEX provides world-class training for fire fighters and other first responders. The facility has an area called Disaster City, which has a multi-story building, partly collapsed parking garage and large rubble pile. In addition, there are other expected urban structures and buildings in various states of damage to assist in training.

The NDTs conducted a course called Collapse Rescue Operations or CRO. The CRO course trained the team on methods and procedures to shore buildings or walls, move large objects with limited tools and no crane or other type support, and the use of breeching and disablement tools such as hammer drills, chop saws, welding torches and similar equipment.

This training is essential as the NDTs may have to operate in an area or on a facility that has been bombed or otherwise has structural damage from military action. The CRO class provides team members skills and hands-on application experience on how to ensure the NDTs are able to access a facility and operate there safely.

NDT members prepare a disablement plan as part of Exercise Liberty Focus.

NDT member uses a notebook computer to sketch information on nuclear infrastrucutre during Exercise Liberty Focus at Ft. Hood, TX[2]

NDT2 Vehicles leave Ellington Field TX for College Station TX as part of Exercise Smokin' Armadillo

Exercise Storax-Poplar - NDT 2 and CBRNE Response Team (CRT) 3A of the 22d Chemical Battalion conducted Exercise Storax-Poplar from 24 -29 January 31, 2011 to test joint NDT and CRT operations and improve tactical skills for exploiting a nuclear or radiological target set. This exercise was the first full scope field training event involving both an NDT and a CRT and by design the exercise scenario tested both teams capabilities and ability to work together and separately in shared operational space.

The addition of a CRT added a new level of complexity. This exercise utilized three targets for assessment and exploitation. In addition Y-12 provided a day of instruction and hands-on training with the disablement tools, providing metal for torch training and concrete for cutting and breaking.

NDT 2 and DOE team members conduct mission planning

Smoking Armadillo- This was a semi-full scale NTNF GSM Validation Exercise, and included robust participation from the DOE, with a smaller footprint from the FBI. The Exercise was held at TEEX, at College Station, Texas, and was a re-validation of NDT 2 to assume the NTNF mission in April 2011. This exercise had an increased level of Incident Command System (ICS) involvement in the scenario which added to realism. In addition the NTNF Task Force set up an actual FOB at the TEEX Riverside campus, and performed collections in "Disaster City". NDT 2 line hauled all of their equipment to Houston, TX and then conducted a 100+ mile convoy operation to College Station.

During this validation iteration the NTNF-GSM rehearsed a new team lineup that now includes four 74D sample collectors from CRT 3A, 22nd Chemical Battalion (TE). In addition to increased ICS interaction, this exercise had the first use of DOE produced "replicant" post-detonation material, giving the collection teams a more realistic sample media to collect than has previously been possible. An added aspect of the exercise introduced "survivors" in the collection area as well as media interaction.

**Conclusion**

The Nuclear Disablement Teams of the 20th Support Command continue to prepare for new missions and maintain readiness to execute their current set of both Disablement and Nuclear Forensics. In both mission areas, the NDTs continue to improve the scope and quality of training and exercises.

Photos 1,2 Courtesy: 20th Support Command (CBRNE) Public Affairs Office

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# NUCLEAR ZERO: WORLD PEACE OR WORLD CHAOS?

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Imagine a world without nuclear weapons - a world free of the specter of nuclear annihilation, free from nuclear terrorism, a world where all nations and all people live in peace and security. This is the world envisioned by President Barack Obama and articulated in a speech delivered on April 5, 2009 in Prague with the words "I state clearly and with conviction America's commitment to seek the peace and security of a world without nuclear weapons."[1] So, with a few simple words, President Obama effectively made "nuclear zero"[2] a goal of U.S. defense and foreign policy.

At first, the goal of nuclear zero seems both admirable and desirable. After all, who could argue that a world with nuclear weapons is preferable to one without? It is only upon further analysis that one begins to question the wisdom, practicality, and the basic premises and assumptions that govern the nuclear zero movement. By systematically and logically considering the technical challenges, economics, security implications, and social-political realities that will inevitably be encountered on the "road to nuclear zero", one quickly, and paradoxically, finds that a world with nuclear weapons may well be preferable to one without. That instead of making the world safer, the road to nuclear zero will actually lead to a world that is more dangerous and less secure.

**Nuclear Weapons and National Security: A Brief History**

In pursuit of nuclear zero, the U.S. "will reduce the role of nuclear weapons in our national security strategy, and urge others to do the same."[3] Substantively diminishing the role of nuclear weapons will mark a tectonic shift in the national security strategy of the U.S., one in which nuclear weapons have been the geopolitical lynchpin since the closing days of the Second World War.

Initially developed under the "Manhattan Project" (1942-1945) to counter a suspected German nuclear weapons[4] program, the first U.S. nuclear device[5] was successfully tested at Alamogordo, New Mexico, on July 16, 1945.[6] Shortly thereafter, with the goal of avoiding a costly amphibious invasion of Japan, the U.S. dropped nuclear weapons on the Japanese cities of Hiroshima (August 6) and Nagasaki (August 9). The weapons had the desired effect, with the Japanese Emperor announcing his nation's unconditional surrender on August 15.[7]

The U.S. nuclear monopoly was short-lived as the Soviet Union, using a design gained through espionage, detonated its first nuclear device on August 29, 1949 in Kazakhstan.[8] The Soviet nuclear test came years in advance of when the U.S. believed it would likely occur. This strategic surprise both heightened the Cold War and initiated the nuclear arms race – an arms race which would dominate U.S. and Soviet defense strategies for the next forty plus years. During the nuclear arms race, the Soviet nuclear arsenal eventually grew to an estimated 40,723 nuclear weapons by 1986, while the U.S arsenal peaked at 32,193 in 1966.[9] Yet despite the tensions of the Cold War, associated proxy wars in Korea, Vietnam, and Afghanistan, the large nuclear arsenals possessed by both sides, and a couple of close calls (most notably the 1962 Cuban Missile Crisis[10] and the 1983 NATO exercise ABLE ARCHER[11] ), no nuclear weapons have been used in anger since World War II.

The fact that neither a nuclear exchange between the U.S. and the Soviet Union, nor a large-scale conventional war in Europe between NATO and the Warsaw Pact occurred during the Cold War, can largely be credited to the inherent deterrent effect of the nuclear weapons possessed by both sides. With the awesome, unprecedented destructive power[12] of even the first, most basic nuclear weapons, it quickly became evident to both the U.S. and the Soviet Union that these were not "normal" military weapons, but were instead weapons whose true value lies not with their destructive power, but in the political power and prestige ("superpower" status) they bestowed and the deterrent value they granted. This realization did not come immediately, however.

Military and civilian planners in both the U.S. and the Soviet Union contemplated a number of nuclear warfare strategies such as countervalue, counterforce, devastating first strike, and decapitation[13] before concluding that any nuclear exchange would result in unacceptable friendly casualties and run the risk of initiating a full-scale nuclear war. With the development of thermonuclear weapons[14], "mutually assured destruction" became the inevitable result of any full-scale or near-full-scale nuclear exchange forcing both sides to conclude that the primary value (if not sole value) of their nuclear arsenals

was in their deterrent value. As long as both sides possessed credible nuclear capabilities, no military advantage would be gained by using nuclear weapons, and direct conventional conflict between the superpowers would be too risky due to the real possibility of escalation to a nuclear exchange.

The end of the Cold War and improved U.S. relations with Russia greatly reduced both the numbers of deployed nuclear weapons and the risk of global thermonuclear war, but did not bring about the end of nuclear weapons nor end their role as an important element of U.S. (and Russian) national security. The current role of nuclear weapons in U.S. national security is laid out in the 2010 Nuclear Posture Review (NPR)[15] which "outlines the Administration's approach to promoting the President's agenda for reducing nuclear dangers and pursuing the goal of a world without nuclear weapons, while simultaneously advancing broader U.S. security interests."[16] The NPR describes the five key objectives of U.S. nuclear weapons policies and posture:[17]

1) Preventing nuclear proliferation and nuclear terrorism;
2) Reducing the role of U.S. nuclear weapons in U.S. national security strategy;
3) Maintaining strategic deterrence and stability at lower nuclear force levels;
4) Strengthening regional deterrence and reassuring U.S. allies and partners; and
5) Sustaining a safe, secure, and effective nuclear arsenal.

These objectives are also reflected in the 2010 National Security Strategy [18] (NSS). Along with reiterating the goal of nuclear zero, the NSS describes the need to prevent violent extremist organizations (VEOs) from acquiring nuclear weapons, preventing the spread of nuclear weapons, securing vulnerable nuclear materials, strengthening the Nuclear Nonproliferation Treaty, seeking a treaty to end the production of fissile materials for nuclear weapons, and reducing the numbers and role of nuclear weapons. As with the NPR, however, the NSS acknowledges the continuing deterrent role of nuclear weapons[19] and, as long as nuclear weapons exist, the need to maintain "a safe, secure and effective nuclear arsenal".[20] These basic objectives are also reflected in the Quadrennial Defense Review Report,[21] the National Military Strategy,[22] and the National Defense Strategy.[23] (Note: The current National Defense Strategy document published in 2008 pre-dates the current Administration and does not reflect the goal of nuclear zero.)

**From Arms Control to "Ban the Bomb" to Nuclear Zero**

The goal of nuclear zero is not new. Even before the bombings of Hiroshima and Nagasaki, Leó Szilárd, the scientist who first envisioned the nuclear chain reaction process (and hence the possibility of nuclear energy and nuclear weapons) and who had worked on the Manhattan Project, circulated a petition among scientists working on the bombs urging the U.S. Government not to use the bombs on Japan.[24] Shortly after the war, two diametrically opposed ideas surfaced on how the world should deal with this new type of weapon. The Acheson-Lilienthal Report advocated making nuclear technology and knowledge of how to make nuclear weapons available to all (basically an "Anti-Nuclear Nonproliferation Treaty"). The theory was that this would remove "the element of rivalry between nations"[25] and, presumably, reduce the likelihood of nuclear conflict and conflict in general. At the other extreme was the Baruch Plan which suggested that the U.S. give up its nuclear arsenal, as long as others did the same.[26] Both plans ultimately failed to be accepted as distrust of the Soviets was already growing within the U.S. and in Europe. Interestingly (and somewhat predictably), the Soviet response to the Baruch Plan was to propose "immediate and universal nuclear disarmament without inspection.[27]"

Today, the primary diplomatic tool used to try to prevent the spread of nuclear weapons among nations is the legally binding Nuclear Nonproliferation Treaty (NPT) which entered into force on March 5, 1970. The objectives of the NPT are to: "stop the spread of nuclear weapons; provide a sound basis for international cooperation on the peaceful uses of nuclear energy; and commit all Parties to undertake negotiations in good faith on disarmament".[28] The NPT currently boasts 189 signatories, making it one of the most universally agreed to treaties in existence. Of note, however, are the three countries who have not signed the NPT – India and Pakistan who have both openly tested nuclear weapons, and Israel who is strongly suspected of possessing a nuclear arsenal.[29]

Historically, the declared nuclear weapons states (i.e., U.S., Russia, China, United Kingdom, and France) have been criticized by many of the non-nuclear weapons states for not making a serious attempt at disarmament as prescribed by the NPT. The adoption of nuclear zero as official U.S. policy is the most recent and the most ambitious attempt to address this criticism, but is not the first. The first tangible steps towards the goal of nuclear disarmament and for diffusing the nuclear tensions of the Cold War were the series of arms control agreements signed between the U.S. and the Soviet Union (now Russia). The first of these agreements, the Strategic Arms Limitation Talks agreement (SALT I) was signed in 1972. This was followed by the 1979 SALT II agreement (which never entered into force), the 1991 Strategic Arms Reduction Treaty (START I), START II (which also never entered into force) in 1993, the 2002 Strategic Offensive Reductions Treaty (SORT), and most recently the 2010 New START agreement which reduces the number of deployed strategic warheads on both sides to 1,550.[30] These strategic arms agreements were complemented by the 1987 Intermediate-Range Nuclear Forces (INF) Treaty which verifiably eliminated "all ground-launched ballistic and cruise missiles with ranges between 500 and 5,500 kilometers"[31] and the 1991 Presidential Nuclear Initiative by which the U.S. unilaterally removed all tactical nuclear weapons (i.e., artillery shells, short-range missile warheads, etc.) from deployment.[32]

Meanwhile, both in the U.S. and in Europe the fear of a possible nuclear war and dissatisfaction over rising

defense budgets fueled a growing anti-nuclear movement - a movement that had originated in the 1950's amid growing public concerns over the environmental and health effects of above-ground nuclear testing.[33] These concerns, combined with growing uneasiness over the accelerating nuclear arms race, soon bred the "Ban the Bomb" movement in the U.S. and Europe, and spawned such anti-nuclear groups as Federation of Atomic Scientists, the National Committee for a Sane Nuclear Policy, the Campaign for Nuclear Disarmament, International Physicians for the Prevention of Nuclear War, Greenpeace, and others.[34] Having been unsuccessful in bringing about nuclear disarmament, the anti-nuclear movement largely changed its message from "ban the bomb" to "nuclear freeze" by the time the 1970's drew to a close.

In addition to being driven by the same general concerns as the "Ban the Bomb" movement (mainly the nuclear arms race and growing defense budgets), the Nuclear Freeze movement drew extra strength and public support from both the failure of the U.S. to ratify the SALT II treaty[35] and the impending deployment of Pershing II intermediate-range nuclear missiles to Europe by the U.S.. The Nuclear Freeze movement "called on the U.S. and Soviet Union to adopt a mutual freeze on the testing, production, and deployment of nuclear weapons and of missiles, and new aircraft designed primarily to deliver nuclear weapons."[36] Though the freeze movement resulted in a number of large demonstrations in the U.S. and across Europe in the early 1980's, it did not succeed in actually getting either the U.S. or the Soviet Union to implement a nuclear freeze policy. (The Soviet Union did agree to support a freeze proposal at the United Nations in 1982, however.)[37]

The end of the Cold War and significant cuts in the nuclear arsenals of both sides temporarily quieted the anti-nuclear movement. As fears of nuclear proliferation and nuclear terrorism began to grow in the late 1990's and early 2000's, a new nuclear disarmament movement began to take hold – "Global Zero". Officially launched in 2008, the Global Zero movement advocates the belief "that the only way to eliminate the nuclear threat — including proliferation and nuclear terrorism — is to stop the spread of nuclear weapons, secure all nuclear materials and eliminate all nuclear weapons."[38] Unlike the anti-nuclear and disarmament movements of the past, the Global Zero movement has the open support of a growing number of high-profile current and former politicians including former Secretaries of State Henry Kissinger and George Schultz, and former U.K. Prime Minister Gordon Brown, among others. More significantly, however, the Global Zero movement has the public support of not only a growing number of non-nuclear weapons states, but also of both President Medvedev of Russia and President Obama, who has made the goal of nuclear zero official U.S. policy. In February, 2010, the Global Zero movement published its plan of how it believes nuclear zero can be achieved by the year 2030.

**Global Zero: The Plan, the Issues, the Consequences**

The "Global Zero Action Plan" (which, significantly, has not been officially agreed to by any nation) lays out the steps the organizers of the Global Zero movement believe are needed to achieve a world free of nuclear weapons.[39] The plan describes a four-phase approach to achieve the goal of nuclear zero by the year 2030. In Phase 1 (2010-2013), the U.S. and Russia are to negotiate a follow-on treaty to New START reducing the number of warheads to 1,000 per side by 2018. Meanwhile, all other nuclear weapons states would agree to freeze their arsenals at current levels and prepare for multi-lateral talks. During Phase 2 (2014-2018), the U.S. and Russia are to further reduce their arsenals to 500 warheads each by 2021. This will be done in a multi-lateral framework in which the other nuclear weapon states are assumed to maintain the freeze until 2018 when they too will begin proportionate reductions to the year 2021. These reductions will be accompanied by a strengthening of the safeguards on the civilian nuclear fuel cycle to prevent the diversion of weapons-grade and weapons-usable material for nuclear weapons and a comprehensive verification and enforcement system, the hallmark of which will be no-notice, on-site, inspections. In Phase 3 (2019-2023), an international, legally binding "Nuclear Zero Accord" will be signed by all nuclear capable[40] nations "for the phased, verified, proportionate reduction of all nuclear arsenals to zero total warheads by 2030."[41] Finally, in Phase 4 (2024-2030), in a phased, proportionate, and verifiable manner, all nuclear weapons would be eliminated, and production of new weapons prohibited. The verification and enforcement system would continue indefinitely.

Though not going into specifics, the Global Zero Action Plan acknowledges that "nations will confront profound and complex political and security issues"[42] on the road to nuclear zero, and that the process for getting there will be "long and difficult." Naturally, the plan's supporters believe that all these issues can be overcome and that the desired end state – a world free of nuclear weapons – is both achievable and desirable. In reality, however, believing and hoping for something to be true does not make it so, no matter how admirable, pure, and good that something may be. Before embracing this plan and the goal of nuclear zero, the U.S must seriously question the assumptions upon which this plan rests and address the whole range of issues that must be overcome to make a world without nuclear weapons more than a dream.

The first, and perhaps foremost, set of challenges confronting nuclear zero are technical ones. These challenges are rooted in both the nature of science and discovery and in the feasibility of a verification and accountability regime that must be absolutely perfect for nuclear zero to work. Nuclear weapons and the knowledge on how to make them exists, that is a fact. Though it may be physically possible to eliminate all nuclear weapons, it is impossible to completely purge the world of the knowledge of how to construct them. Once something is invented, it can't be "un-invented". The basic knowledge of how to construct a simple nuclear weapon exists, and will continue to exist, in the historical record, in documents, in books, in computer files,

on the internet, and most importantly in the minds of the world's nuclear engineers and physicists. Documents and computer files can be eliminated, an idea cannot. If nuclear zero is nominally achieved, nuclear weapons are no longer being produced or designed, and a concerted effort is made to destroy all existing nuclear weapons design information (a step not in the Global Zero Action Plan), then eventually the knowledge of sophisticated nuclear weapons designs may fade from the collective consciousness – but the concept of nuclear weapons and the knowledge of their basic design will not.

The knowledge of nuclear weapons and how to make them will continue to exist because nuclear engineers and physicists will continue to be needed to design, develop, and run the world's growing nuclear power infrastructure (Fukushima Daiichi disaster and Germany's recent decision to forgo nuclear power notwithstanding). Acknowledgment that nuclear power is essential for combating climate change and replacing dwindling supplies of fossil fuels is growing, even among many who previously opposed nuclear power.[43] Though the nuclear engineers needed for the growing nuclear power industry will be educated and trained to design nuclear reactors, not nuclear weapons, the fact is that if one can design a reactor, one can also design a basic nuclear weapon.

Knowledge alone is not enough to build a nuclear weapon; one also needs a minimum amount of appropriate fissile material (usually Uranium-235 or Plutonium-239). According to the International Atomic Energy Agency (IAEA), a "significant quantity" is 8 kg of Plutonium-239, 25 kg of highly-enriched (>90%) Uranium-235, or 75 kg of low-enriched or natural uranium.[44] Here, a significant quantity is defined by the IAEA as "the approximate quantity of nuclear material in respect of which, taking into account any conversion process involved, the possibility of manufacturing a nuclear explosive device cannot be excluded."[45] So, for a verification regime to be completely effective, it would have to account for all existing supplies of these materials down to this level of accuracy within each nuclear-capable state (and everywhere else) to ensure that no single actor was able to obtain these quantities of material outside the verification regime. This would be particularly challenging since there is estimated to be over 2,000 tons of weapons-grade fissile material in existence today worldwide,[46] with more than 1,000 tons of highly-enriched uranium (HEU) and 150 tons of weapons-grade plutonium residing in Russia's remaining nuclear complex (enough to build approximately 60,000 nuclear weapons).[47]

Compounding the verification problem is that uranium would continue to be mined, processed, and enriched for the nuclear power industry, even after nuclear zero took effect. The Global Zero Action Plan specifically tries to address this concern in Phase 2, in which "the entire fuel cycle of all countries" would be put under international safeguards, a possible international fuel bank would be established, and where the fuel cycle management for uranium enrichment and plutonium reprocessing would be placed under international control.[48] The international safeguards, management, control, and fuel bank aspects of this plan raise difficult sovereignty issues, especially for nations who heavily depend on nuclear power. Under such a system, a nation could conceivably be denied nuclear fuel if it ran afoul of international opinion. It is hard to imagine an independent-minded nation like France that depends so heavily on nuclear power[49] effectively giving up that level of control and authority to the international community.

More seriously, the Global Zero Action Plan does not adequately address the problem it really wants to solve - preventing the use, by anyone, of a nuclear weapon. Today, the biggest security concern from nuclear weapons is the possible detonation of a nuclear-yield producing improvised nuclear device (IND)[50] in an urban area by a violent extremist organization (VEO). To carry out such an attack, a VEO would need to either steal or illicitly obtain a state-produced nuclear weapon or obtain a sufficient amount of either HEU or weapons-grade plutonium to fabricate a simple gun-type or implosion-type nuclear device. The probability of a VEO stealing a complete functioning nuclear weapon from a state actor, transporting it to the target undetected, overcoming all its use-control features, and detonating it is so low that it is not generally considered to be a credible threat. The more likely scenario is a VEO obtaining enough nuclear material, from a stolen weapon or another source, to build a crude yield-producing IND. As such, the best way to prevent such an event is to improve the security and use-control features of nuclear weapons worldwide, secure all HEU and weapons-grade plutonium from theft or diversion, and deny VEOs access to nuclear expertise. A large number of effective efforts are already underway outside the auspices of Global Zero to do just that. These include the Proliferation Security Initiative (PSI)[51], the Cooperative Threat Reduction (CTR)[52] Program and the associated Global Nuclear Lockdown Initiative[53], the Nuclear Cities Initiative[54], the International Nuclear Materials and Protection Cooperation Program (INMPC)[55], the Global Threat Reduction Initiative (GTRI)[56], and the Fissile Material Cutoff Treaty[57] among others. Except for its Phase 2 efforts to better safeguard the civilian nuclear fuel cycle, the Global Zero Action Plan does little to substantively reduce the threat of a VEO detonating an IND.

Instead of focusing on the VEO/IND threat, Global Zero's main emphasis is on having state actors eliminate their nuclear arsenals in order to, in theory, preclude the possibility of a state-to-state nuclear exchange. Certainly if all state actors did indeed reduce their arsenals to zero, and did not attempt to cheat the system (more on this later), the threat of a state-to-state nuclear exchange would be removed (as would the already low probability event of a VEO stealing or otherwise obtaining a state-produced nuclear weapon). Even without nuclear zero, however, the likelihood of a state-to-state nuclear exchange is very low due to both the deterrent effect of nuclear weapons and the devastating consequences such a nuclear exchange would bring to both sides. Although traditional nuclear deterrence is unlikely to be effective against VEOs

themselves, it is still effective with regard to state-to-state interactions and against any state with thoughts of providing a nuclear weapon to a VEO.

Supporters of Global Zero often state either that "whatever stabilizing impact nuclear weapons had during the Cold War, any residual benefits of these arsenals are now overshadowed by the growing risk of proliferation and the related risk of nuclear terrorism"[58] or that state-to-state deterrence using nuclear weapons is "becoming increasingly hazardous and decreasingly effective."[59] Is this really the case? History tells us that in the sixty plus years since nuclear weapons were invented there has never been a state to state-nuclear-exchange. Of course that does not mean that one is not possible, but it does indicate that states have not taken the use of nuclear weapons lightly and, to date, have been loathe to break the "nuclear taboo". One can also argue convincingly from the historical record that the possession of nuclear weapons has been instrumental in preventing a number of direct large-scale state-to-state conventional conflicts from occurring - Warsaw Pact versus NATO, India versus Pakistan, and a coordinated attack against Israel by its neighbors.

Given their proven deterrent effect in preventing both nuclear and conventional conflict, it is very difficult to make the case that simply eliminating nuclear weapons will make the world safer. It is doubtful that Israel, Pakistan, and India will feel "safer" without their nuclear arsenals. Removing Israel's ability to hold its enemies at existential risk will just invite attack. Removing the ability of Pakistan and India to hold each other at existential risk makes the likelihood of a large-scale conventional conflict that much greater. Even for the U.S. and Russia, the road to zero would be a perilous one, for as arsenals approach zero, the security consequences of cheating would multiply as would the risk from other nations suddenly emboldened by the absence of the threat of nuclear retaliation. Taking away a nation's ability to hold another nation at existential risk does not make that nation more secure, it does just the opposite.

Although not explicitly stated as a goal of nuclear zero, it is also widely assumed that significant economic savings would be realized if the world's nuclear arsenals were reduced to zero. If nuclear weapons were no longer a part of the U.S. defense infrastructure, what would they be replaced with? The idealist might say that they need not be replaced with anything due to the increased "safety" inherent in a world free of nuclear weapons. The geopolitical realities of a world of diverse nations competing for finite resources and of clashing ideologies will certainly dictate otherwise. At a minimum, the elimination of nuclear weapons will require larger-sized conventional forces of increased capabilities and modernized weapons systems – expensive propositions all. Even more expensive, however, would be a potential new arms race to develop a new type of weapon of mass destruction, outside current arms control regimes, to replace the capability lost through nuclear zero. From an economic perspective, the security provided by the current levels nuclear weapons may ultimately be deemed a "bargain" compared to the nuclear zero alternative.

Even if new expenditures on conventional forces or new weapon systems were minimized or avoided, the overall savings realized from the elimination of nuclear weapons may still not be as great as hoped by policy makers and Global Zero advocates. Even if nuclear zero was nominally achieved, the U.S. could not assume that the probability of a nuclear strike on the U.S. homeland or against deployed U.S. forces would be zero. No verification and monitoring system can be assumed to be perfect, and the possibility of VEO use, cheating, or of a now former weapons state clandestinely reconstituting a nuclear weapons program cannot be assumed away. As such, weapons systems and other critical assets and infrastructure would still need to be survivable against electromagnetic pulse (EMP) and other nuclear weapons effects. To do otherwise would encourage such an attack. Similarly, research and development in the areas of nuclear survivability, nuclear detection, nuclear weapons effects, nuclear forensics, missile defense, and consequence management would continue, though likely at some reduced level.

As pointed out earlier, a world free of nuclear weapons does not equate to a world without nuclear technology. In addition to the increased role of nuclear power in meeting the world's energy demands, nuclear technology will continue to be used in a wide and increasing range of medical and industrial applications. As such, the risk of a VEO employing a radiological dispersal device (RDD) or a radiological exposure device will remain, thereby necessitating that our radiation portal monitoring systems at ports, border crossings, and other key locations continue in operation and continue to be improved. Similarly, research and development in the area of radiation detection in general would continue in order to improve routine monitoring and targeted search operations and, presumably, to support the nuclear zero verification regime.

With the continued existence of nuclear technology, particularly for uranium enrichment and fuel reprocessing, comes the possibility of the diversion of nuclear material and cheating. Though a stringent verification regime is part of Global Zero, no verification regime can be guaranteed to be perfect. Even in today's non-proliferation verification and monitoring environment, cheating is almost certainly occurring in Iran and North Korea, posing serious security concerns to the world community. In a nuclear-zero world, where the U.S. and all others have eliminated all their nuclear weapons, the consequences of a nation cheating and producing a crude nuclear weapon are far more severe. In such a world, a nation with even one nuclear weapon holds the power to threaten any other nation without the fear of retaliation in kind.

Global Zero's verification regime, if implemented as written, will certainly make it difficult for cheating to occur, particularly for nations who did not previously possess their own nuclear weapons program. For nations that did previously have such a program, cheating would be significantly easier to accomplish, in spite of the verification regime. Such a nation could secretly store the technology needed to quickly re-

constitute a nuclear weapons program; produce nuclear materials needed for a weapon at a secret facility constructed prior to Global Zero; or possibly even hide a small number of nuclear weapons in order to reveal them when needed.

It is safe to assume that nations that live up to all their treaty obligations today would also do so as signatories to Global Zero. It is equally reasonable to believe that nations that have had a history of not living up to their treaty obligations and who have operated in a culture of secrecy and obfuscation will continue to do so, even if they sign onto Global Zero. For the U.S. to give up its nuclear deterrent in such an uncertain environment is naïve at best. If the U.S. does give up its nuclear deterrent and the assurance it provides to its allies, less scrupulous nations will cheat within the Global Zero regime to take advantage of the situation to threaten the security of the U.S. and its allies. To believe that just because the nations of the world have agreed to Global Zero they will all suddenly become good world citizens, even when they were not before, is dangerously unrealistic and runs contrary to basic human nature and common sense.

Cheating will occur in a Global Zero world, just as it does today (Iran and North Korea with respect to the NPT, for example). No verification regime can absolutely prevent it. Though the analogies are far from perfect, the U.S. can simply look to how effective its "ban" on alcohol was during the Prohibition Era, or how effective gun control has been in cities that have tried it, or to the overwhelming failure of the "War on Drugs" to convince itself that when something is banned, people will find a way to cheat regardless of the efforts to prevent it. From a human perspective, it is not the nuclear weapons themselves that lead to violence; it is the nature of people. That is an issue debated by the philosophers and theologians over the centuries. A nuclear-free world, like world peace, is a wonderful dream and we can hope for those who believe and pray that it will become a reality. However, as long as there are those who seek to gain and wield power for the purpose of controlling others and forcing an ideology or perspective on others, we will need to maintain our expertise in the weapons and science of the day.

**Envisioning a World without Nuclear Weapons**

Assuming that all the technical, security, economic, geopolitical, and social barriers were overcome, what would a world without nuclear weapons look like? How would the U.S. National Security Strategy change? Would there be more peace or less? Would we be more secure or less? Though the future is unknown, it is possible to speculate what that future may look like based on current trends, history, and basic human nature.

As previously discussed, the role of nuclear weapons in U.S. security strategy is primarily laid out in the NPR and reiterated in the NSS. In the absence of nuclear weapons, presumably there would no longer be any need for a NPR, but its objective of "preventing nuclear proliferation and nuclear terrorism" (echoed in the NSS) would remain relevant. Clearly, the key to nuclear zero's success will be a strong, enforceable verification regime to prevent cheating and hence proliferation and nuclear terrorism. If recent history is any indication, the U.S. will likely find itself as the "world's primary enforcer" of this verification regime, requiring conventional and specialized forces trained and equipped for the task. This will be a difficult mission requiring forces equipped with latest in radiation detection technology informed by a comprehensive system of intelligence, surveillance, and reconnaissance – none of which will come cheaply.

More profound, however, will be the removal of nuclear deterrence from U.S. national security and the security of the other known and suspected nuclear weapons states. Historically, nuclear deterrence has provided great motivation for nuclear-armed nations to avoid direct conflict and has allowed them to "hedge" on the size of their conventional forces. This will no longer be the case once nuclear zero takes effect. With the restraint imposed by nuclear weapons removed, direct conventional conflict will become more likely and more destructive. Eliminating nuclear weapons will not bring about world peace and the end of conflict; it will likely have just the opposite effect.

With all the difficult and complex issues to be overcome, it seems highly unlikely that nuclear zero can be achieved solely though political means. For some nations (Israel, for example) the security provided by nuclear weapons is too important to their national survival to just give away. To work, nuclear zero requires universal acceptance and compliance - without it the entire framework collapses. Human nature and history tell us that cheating will occur; to believe otherwise is folly. The stakes are too high for cheating not to occur. For in a world nominally free of nuclear weapons, a nation that breaks its nuclear-zero commitment and suddenly emerges with just a few nuclear weapons will be in a position of great power. The idea that nations, particularly nations that currently have nuclear weapons, will leave themselves vulnerable to such strategic surprise and peril by going to nuclear zero seems highly improbable.

Nuclear zero may indeed be achieved someday, but it will not be through purely negotiated or political means as outlined in the Global Zero Action Plan. Like weapons systems of the past, nuclear weapons too may someday become obsolete. Not because they have been negotiated away, however, but because they have been replaced by something else - something more effective, equivalently destructive, with fewer residual effects, and easier to produce. Ironically, nuclear zero may hasten the development of such follow-on systems. Another path to nuclear zero would be for the world to develop the genuine collective political will to renounce nuclear weapons and actively and aggressively enforce a ban, not just attempt to verify it. This likely would only happen, however, in the aftermath of either a state-to-state nuclear exchange or the use of a nuclear weapon by a VEO. Unfortunately, this scenario may play out sooner, rather than later. The 2008 report by the bipartisan Commission on the Prevention of Weapons of Mass Destruction predicts that a WMD attack (more likely biological than nuclear) will occur by the end of 2013.[60]

Though noble in its intentions, the utopian goal of nuclear zero is simply not realistic at this time. The barriers to its implementation are simply too high and too profound to be overcome solely through political means. Paradoxically, instead of bringing peace, removing the restraint imposed by nuclear weapons will more likely result in more conventional conflict and the development of even more destructive weapons. Weakening the nuclear deterrent will not make the U.S. or the world more secure, it will only invite aggression. Even more dangerously, nuclear zero does little to directly address the most probable threat from nuclear weapons today – use by a VEO. Instead of a quixotic pursuit of a mythical world of nuclear zero, the U.S. should redouble its ongoing efforts to secure all nuclear materials worldwide to prevent possible VEO use – real and tangible efforts that actually will make the world safer now and in the future.

**Author Biographies**

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*Lieutenant Colonel Andreas Tschakert, German Army. Lieutenant Colonel Tschakert is member of the German Armed Forces and currently serves in the Division of Army Armament in the Army Office, Cologne, Germany. He was trained as Air Defense Officer by trade and served in several Air Defense career field positions. He was assigned Battery Commander of a SHORAD Battery and Commander of a Staff and Supply Battery of the Air Defense Training Battalion, before working as S3 of an Air Defense Battalion in the past. He will serve in his current position after his return to Germany.*

**End Notes**

1. http://www.whitehouse.gov/the_press_office/Remarks-By-President-Barack-Obama-In-Prague-As-Delivered/
2. The term "nuclear zero" is also sometimes referred to as "global nuclear zero" or simply "global zero" by its proponents. All three terms will be used interchangeably throughout this paper.
3. http://www.whitehouse.gov/the_press_office/Remarks-By-President-Barack-Obama-In-Prague-As-Delivered/
4. In the terminology of the times, what we now refer to as nuclear weapons were then called "atomic bombs". For consistency, the term nuclear weapon will be used throughout this paper. For an account of the German nuclear weapons program during the World War II era, *see Heisenberg's War: The Secret History of the German Bomb* by Thomas Powers.
5. The term "device" is more properly used here as the system tested was not in a weapon-deliverable configuration. The "Trinity" device tested at Alamogordo, New Mexico, was a plutonium implosion device and was the design basis for the "Fat Man" bomb later dropped on Nagasaki, Japan. There was such a high degree of confidence in the uranium gun-type design, later used in the "Little Boy" bomb dropped on Hiroshima, that no advance test was deemed necessary.
6. Rhodes, Richard, *Making of the Atomic Bomb*, Simon and Schuster, New York, 1986, p. 670.
7. In the years since World War II, much has been written questioning the necessity of using nuclear weapons on Japan (*The Decision to Use the Atomic Bomb* by Gar Alperovitz, *Hiroshima* by Ronald Takaki, and *Hiroshima in America* by Robert Jay Lifton and Gregg Mitchell are a few examples). Second guessing aside, it is clear from the historical record and the operational environment of the time that the nuclear bombings of Japan saved thousands of American lives and likely many thousands more Japanese lives if the fanatical Japanese defenses of Iwo Jima and Okinawa were any indication.
8. Rhodes, Richard, *Dark Sun*, Simon and Schuster, New York, 1995, p. 365. The first Soviet nuclear device tested was copy of the U.S. plutonium implosion "Fat Man" bomb. The design for the bomb was delivered to Soviet operatives by Klaus Fuchs, a German émigré physicist who was part of the British contingent at Los Alamos during the Manhattan Project.
9. Soviet Stockpile Number: http://www.nrdc.org/nuclear/nudb/datab19.asp
U.S. Stockpile Number: http://www.brookings.edu/projects/archive/nucweapons/50.aspx. Note: these totals include both strategic and tactical nuclear weapons.
10. Rhodes, Richard, *Dark Sun*, pp. 570-576.
11. Rhodes, Richard, *Arsenals of Folly,* Alfred A. Knopp, New York, 2007, pp. 163-167.
12. The yield of the Trinity device was 18.6 kT (Rhodes, *Making of the Atomic Bomb*, p. 677), the yield of Little Boy was 12.5 kT (Rhodes, *Making of the Atomic Bomb*, p. 711), the yield of Fat Man was 22 kT (Rhodes, Making of the Atomic Bomb,

p. 740) , and the yield of the first Soviet Device, Joe 1, was ~20 kT(Rhodes, *Dark Sun*, p. 368). One kT is the equivalent explosive force of 1,000 tons of TNT or 4.183 x 1012 Joules.
13. Rhodes, Arsenals of Folly and Kaplan, Fred, The Wizards of Armageddon, Stanford University Press, Stanford, California.
14. Thermonuclear weapons were initially referred to as "hydrogen bombs". The U.S. detonated the first thermonuclear device at Eniwetok atoll on November 1, 1952. This device had a yield of 10.4 MT, or ~1000 times greater than the bomb dropped on Hiroshima (Rhodes, Dark Sun, p. 510). On October 30, 1961 the Soviet Union tested a nuclear device with a yield of 50 MT (http://nuclearweaponarchive.org/Russia/Sovatmtest.html).
15. http://www.defense.gov/npr/.
16. NPR, p. iii.
17. NPR, p. 2.
18. www.whitehouse.gov/sites/default/files/rss.../national_security_strategy.pdf
19. NSS, p. 14.
20. NSS, p. 23.
21. www.defense.gov/qdr/
22. www.defense.gov/news/newsarticle.aspx?id=62736
23. www.defense.gov/news/2008%20national%20defense%20strategy.pdf
24. Rhodes, Making of the Atomic Bomb, p. 697 and http://www.atomicarchive.com/Bios/Szilard.shtml
25. Rhodes, Dark Sun, p. 231.
26. Rhodes, Dark Sun, p. 240.
27. Rhodes, Dark Sun, p. 240.
28. United States Information Pertaining to the Treaty on the Nonproliferation of Nuclear Weapons (2010) located at: http://www.state.gov/t/isn/npt/index.htm.
29. http://www.armscontrol.org/factsheets/nptfact
30. http://www.armscontrol.org/factsheets/USRussiaNuclearAgreementsMarch2010
31. Ibid.
32. Ibid. Note, the Russians made a similar pledge to withdraw its tactical nuclear weapons from deployment, but to date they appear not to have done so. For an excellent summary of the tactical nuclear weapons issue, see the Congressional Research Service (CRS) Report: Non-Strategic Nuclear Weapons, by Amy F. Woolf, http://fpc.state.gov/documents/organization/137264.pdf
33. http://en.wikipedia.org/wiki/Anti-nuclear_movement
34. http://en.wikipedia.org/wiki/Anti-nuclear_movement_in_the_United_States; http://en.wikipedia.org/wiki/Anti-nuclear_movement
35. http://www.culture-of-peace.info/apm/chapter6-15.html
36. Ibid.
37. Ibid.
38. http://www.globalzero.org/en/about-campaign
39. http://www.globalzero.org/en/about-campaign
40. "Nuclear capable states", as defined in the Global Zero Action Plan are "countries with nuclear weapons, weapons-grade fissile materials, uranium enrichment and plutonium reprocessing facilities, or nuclear power or research reactors."
41. Global Zero Action Plan, p. 3. http://www.globalzero.org/en/about-campaign
42. Ibid, p. 4
43. For example, Patrick Moore, one of the founders of Greenpeace, now is a proponent of nuclear energy. http://www.washingtonpost.com/wp-dyn/content/article/2006/04/14/AR2006041401209.html
44. http://www.iaea.org/Publications/Booklets/Safeguards/pia3810.html
45. Ibid.
46. http://www.nuclearterror.org/faq.html#faq_9
47. http://www.nti.org/j_features/j4_threats.html
48. Global Zero Action Plan, p. 7. http://www.globalzero.org/en/about-campaign
49. Currently, France generates over 75% of its electricity with nuclear power. http://www.world-nuclear.org/info/inf40.html
50. An Improvised Nuclear Device (IND) is defined as: "A device incorporating radioactive materials designed to result in the dispersal of radioactive material or the formation of a nuclear-yield reaction. Such devices may be fabricated in a completely improvised manner or may be an improvised modification to a U.S. or foreign nuclear weapon." *Weapons of Mass Destruction Terms Handbook*, DSWA-AR-40H, 1998.
51. http://www.state.gov/t/isn/c10390.htm
52. http://www.nti.org/db/nisprofs/russia/forasst/nunn_lug/overview.htm
53. http://www.thebulletin.org/web-edition/columnists/fissile-materials-working-group/deconstructing-us-funding-nuclear-material-se
54. http://www.y12.doe.gov/missions/nonproliferation/inp/gipp/nuclearcities.php
55. http://www.thebulletin.org/web-edition/columnists/fissile-materials-working-group/deconstructing-us-funding-nuclear-material-se
56. Ibid.
57. http://armscontrolcenter.org/policy/nuclearterrorism/articles/071509_factsheet_fmct/
58. Global Zero Action Plan, p. 2. http://www.globalzero.org/en/about-campaign
59. http://fcnl.org/issues/nuclear/world_free_of_nuclear_weapons/
60. http://www.guardian.co.uk/world/2008/dec/03/terrorism-nuclear-biological-obama-white-house

# Funding the DoE Stockpile Stewardship and Management Program

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The United States nuclear weapon stockpile is aging. The last new nuclear weapon built in 1990. [1] The FY12 Department of Energy (DoE) Stockpile Stewardship and Management Program (SSMP) would implement a comprehensive twenty-five year plan[2] to ensure the viability of all nuclear weapons in the stockpile without underground testing.[3] This program would maintain confidence that these weapons would perform as designed through non-nuclear component testing, computer modeling, and laboratory testing. The program would also extend a weapon's operational lifetime (Life Extension Program (LEP)) using refurbishment, reuse, or replacement of components.[4] The SSMP should be fully funded, because it provides the best program to maintain an effective deterrent while allowing further reductions in nuclear weapons, thus supporting both the President's goals.

What are they?

(1) Long Term-Global Nuclear Weapons Elemination.

(2) Near Term - Credibile Nuclear Deterant.

And President Obama's explained his position on the U.S. nuclear weapon program in his remarks April 2009 in Hradcany Square, Czech Republic.

> "So today, I state clearly and with conviction America's commitment to seek the peace and security of a world without nuclear weapons. I'm not naive. This goal will not be reached quickly – perhaps not in my lifetime. It will take patience and persistence… As long as these weapons exist, the United States will maintain a safe, secure and effective arsenal to deter any adversary, and guarantee that defense to our allies…"[5]

President Obama expressed the U.S. commitment to work toward the ultimate goal of a world without nuclear weapons. This commitment is best exemplified by the Administration signing the New START (Strategic Arms Reduction Treaty) on April 8, 2010, and their successful efforts to gain Senate ratification, with the treaty entering into force on February 5, 2011. [6] President Obama also understands the critical role the U.S. nuclear deterrent plays in our national security. A credible deterrence to our adversaries and assurance to our Allies is created by the capability of the Department of Defense (DoD) to conduct attacks with nuclear weapons delivered via missile, submarine, or aircraft. This capability, and by extension, our deterrence and national security, is then directly supported by the DoE's SSMP.

The Obama Administration reaffirmed its commitment to ensuring an effective stockpile with the FY2013 $7.6B SSMP funding request [7]. However, in September 2011, the Senate Appropriations Energy and Water subcommittee recommended $400M[8] in cuts to the Administration's $7.6B FY12 SSMP funding request. With current concerns about the large Federal budget deficit, this recommendation could be repeated in response to the FY2013 budget request and threaten implementation of the Administration's promised $85B investment in the SSMP over the next ten years.[9] The 2012 and 2013 budget requests were meant to correct chronic SSMP funding deficiencies, assessed in 2006 as "already resulting in triage among demands to sustain a healthy nuclear enterprise. Current capacities are forcing choices between essential areas of work".[10] Any further funding cuts could force cutting of selective programs and thus jeopardize the U.S. stockpile safety, security, and/or effectiveness.

The SSMP funds would allow replacement and modernization of aging DoE laboratories and facilities that Vice President Biden stated was "underfunded and undervalued" for many years.[11] They would also support construction of a new uranium research facility in Tennessee and a chemistry and metallurgy research building in Los Alamos. These facilities would facilitate a better understanding of the effects of aging processes on warhead reliability, especially important since the U.S. stopped testing nuclear weapons over twenty years ago. The budget also funds completion of the life extension study of an aircraft-delivered nuclear bomb, continuation of the LEP for the Minuteman ICBM warhead, and refurbishment of sufficient quantities of submarine-based warheads.[12] Cuts to the budget request would degrade all portions of the SSMP or else severely degrade and perhaps eliminate certain programs, necessitating more expensive fixes later and creating greater risks associated with maintaining an aging stockpile.

Opponents of President Obama's request argue that SSMP funding should be cut because a nuclear stockpile of the

current size is not required to deter threats to the United States and its Allies. They question whether the United States should maintain and enhance an expensive nuclear force, arguing the immense superiority of U.S. conventional forces provides sufficient deterrence. Actually, maintaining nuclear deterrence is even more critical to offset the potential decrease in conventional deterrence that may result from a perception that planned conventional force reductions would decrease U.S. conventional capabilities. As for protection of U.S. Allies, these critics also argue "no one can imagine that the United States would ever use a nuclear weapon on a European battlefield."[13] Following this reasoning, some advocate cuts of up to $26B from the SSMP over 10 years, to include the $251 million LEP for the B61 bomb, versions of which are deployed in Europe. [14]

Significant SSMP cuts would diminish confidence in the effectiveness of the U.S. stockpile, which in turn could severely degrade America's nuclear deterrent. This degradation would occur in an environment where Russia and China are enhancing their nuclear capabilities through modernization efforts. Without a strong SSMP to help maintain our own nuclear forces, America's allies could come to doubt President Obama's assurance in Prague that "they can count on America's security commitments."[15] More importantly, if U.S. allies lost confidence in the U.S. nuclear deterrent, they might embark on their own nuclear weapon programs, as France did in the 1950s. France maintains its own nuclear stockpile even now because it does not want to rely on U.S. extended deterrence and believes a major threat to Europe could occur in the next fifteen to twenty years.[16]

Other opponents question why the United States is increasing expensive stockpile stewardship initiatives if the Administration is truly committed to near-term reductions in weapons stockpiles and to long-term elimination of all nuclear weapons. They argue that a fully funded SSMP undermines U.S. credibility in its efforts to stem further proliferation, because it would appear to endorse the long-term usefulness of nuclear weapons. Actually, a strong SSMP would allow further U.S. reductions in nuclear weapons. Out of 5113 warheads in the stockpile, a couple thousand warheads are kept in the "inactive" stockpile as potential replacements to hedge against problems with warheads in the "active" stockpile.[17] A strong SSMP would increase confidence in the reliability of warheads in the active stockpile and reduce the need for an oversized inactive stockpile, allowing significant reductions.

Even George Schultz, former U.S. Secretary of State, and a leading advocate for the elimination of nuclear weapons,[18] argued that "investments are urgently needed" to help the nuclear weapons laboratories "attract, develop, and retain the outstanding scientists, engineers, designers, and technicians we will need to maintain our nuclear arsenal."[19] The U.S. investment in the SSMP would help bolster not just the nuclear weapons laboratories, but also the human capital at dozens of supporting laboratories and university programs. These science, technology, and engineering investments are balanced and integrated to the maximum extent possible among multiple DoE programs, to include non-proliferation programs. Thus, SSMP funding enhancements would have far reaching impacts on future U.S. scientists intelectual capital developments and engineers and the technology base they help to support. Investment in SSMP is an investment in the United States' future scientific and technological edge.

Fully funding the U.S. SSMP will help ensure a safe, secure, and effective nuclear weapon stockpile. Funding will bring a nuclear weapon complex up to a level where tradeoffs and offsets are not required within critical programs. Funding is also critical to deterring threats to the United States and its Allies. Further, its deterrence effect could offset possible loss of deterrence from planned conventional force reductions. A strong SSMP would allow further stockpile reductions without degrading operational effectiveness by reducing the number of warheads required as a hedge against possible failures. Contrary to critics' views and conventional wisdom, the SSMP budget request certainly aligns well with President Obama's non-proliferations goals enroute to a world without nuclear weapons. Vice President Biden highlighted the crux of this budget issue during remarks in February 2010 at National Defense University, "guaranteeing our stockpile, coupled with broader research and development efforts, allows us to pursue deep nuclear reductions without compromising our security." [20] Congress understands the connection between a strong SSMP and our nation's security, and should fully fund the FY2013 SSMP budget request.

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# The Continuing Nuclear Military Revolution

Major Jason G. Anderson

*The way to win an atomic war is to make certain it never starts.* Omar N. Bradley

Albert Einstein once said, "I do not believe that civilization will be wiped out in a war fought with the atomic bomb. Perhaps two-thirds of the people of the earth will be killed." [1] This quote from one of the key inventors of the atomic bomb has set the stage for the last 65 years of warfare. The atomic bomb was not only a revolutionary new weapon, but one that defined both a military revolution (MR) and a revolution in military affairs (RMA).[2,3] To understand this complex interaction on how one weapon did both, there must be an understanding of both terms and the perpetuation, even today, of the strategic value of being able to wipe out a civilization in a single maneuver.

There is some controversy as to whether the terms MR and RMA were developed by either the United States or the former Soviet Union (Russia).[4] The historian Williamson Murray first proposed prior to writing his book, The Dynamics of Military Revolution 1300-2050, "Military revolutions recast the nature of society and the state as well as of military organizations." whereas RMA's, "involve putting together the complex pieces of tactical, societal, political, organizational, or even technological changes in new conceptual approaches to war." [6] The dropping of the atomic bombs on Hiroshima and Nagasaki at the end of World War II, a technological RMA, spawned the future global MR. The American people had no idea that by ending one war they would immortalize warfare even during times of relative peace.

## The COLD WAR

During the Cold War, a period marked by the end of World War II to the fall of the Berlin Wall, the threat of nuclear war shaped American society even though no nuclear bombs or missiles were ever used in anger. During this time, the United States was involved in two major conflicts, Korea and Vietnam, and multiple covert actions. Sun-Tzu said, "The army values being victorious; it does not value prolonged warfare."[7] If this is the case, then why weren't nuclear devices used in either of the two major conflicts? Books have been written about this subject, but in essence its psychological fear, as the Cold War continued, the ways and means of delivery and effect of nuclear weapons increased so dramatically, that one bomb being employed no longer equaled victory, but mutually assured destruction (MAD). Unbeknownst to most citizens today, the US is still in this predicament.[8] MAD is, "An evolutionary defense strategy based on the concept that neither the United States nor its enemies will ever start a nuclear war because the other side will retaliate massively and unacceptably."[9] This led the U.S. to develop a policy of limited warfare and containing the threat of nuclear war through economic and diplomatic means.

"The most important consequence of the war was the vast increase in the U.S. defense budget."[10] Figure 1, from Carl Conetta, co-director of the Project on Defense Alternatives, shows from the Korean War to 2019 an increase in defense spending. Embedded in those spending plans was the development of the nuclear arsenal.[11] On December 1, 1950, "Executive Order 10186 created Federal Civil Defense Administration (FCDA) within Office for Emergency Management, Executive Office of the President."[12] This enabled the people of the United States to be prepared for a nuclear war by purchasing fall-out shelters, stock piling food, and participating in emergency drills. With the majority of Americans behind the Defense Department's strategic "first strike"[13] deterrence policy, the societal MR was institutionalized and the nuclear arms race was perpetuated throughout the rest of the Cold War.

On one occasion, during the height of the Cold War, the world stood by locked in fear. The Cuban Missile Crisis, October 1962, was a turning point for diplomatic relations between the US and USSR.[14] Both countries agreed to pull out the nuclear missiles in Cuba and Turkey (the USSR publicly and the US privately) and a direct communication telephone and telefax were established between the US and USSR less than six months later.[15] This ensured that the leaders of the two countries with the most nuclear weapons could quikly address issues diplomaticly rather than initiating WWIII.

## The LAST 20 YEARS

Since the end of the Cold War, the threat of terrorism and rogue nation states has driven US Defense policy. With the thought of one of these groups acquiring or using a nuclear weapon always at the forefront of that policy. The Department of Homeland Security (DHS), which was created in response to and after the terrorist attacks on

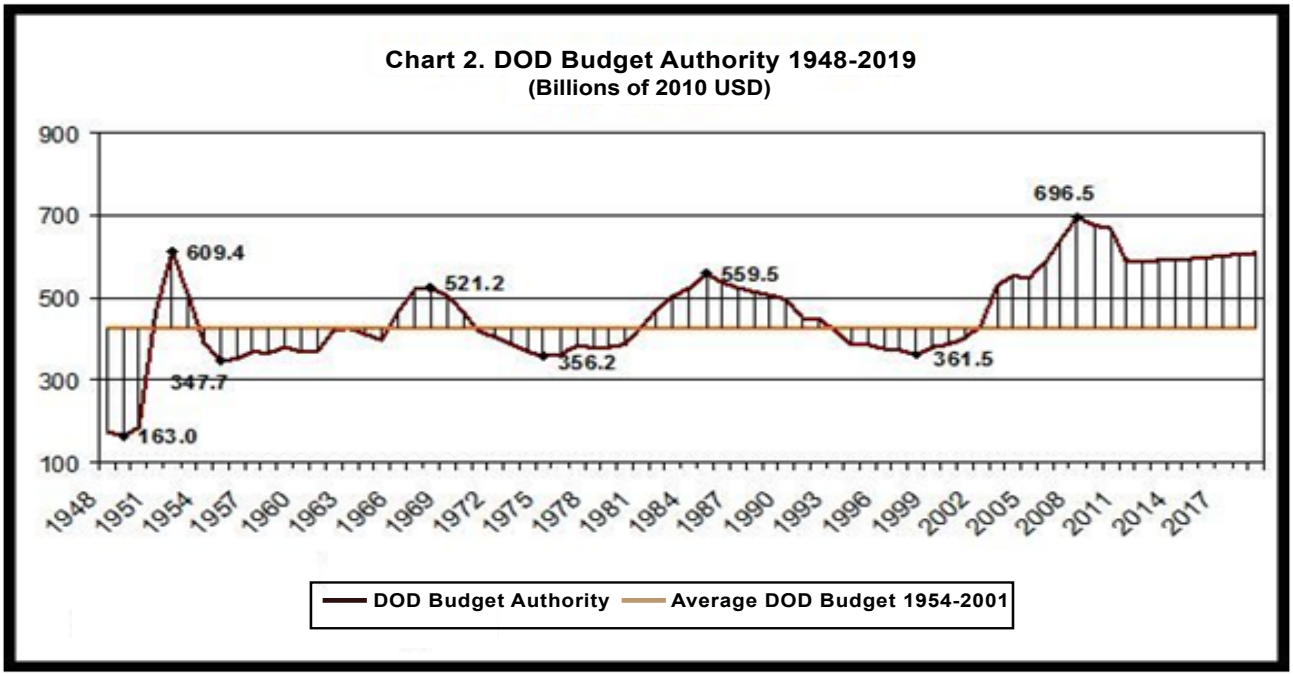


Figure 1

September 11, 2001 also maintains the same policy. According to Fred Ikle, the former Under Secretary of Defense for Policy, "Democracy cannot survive in a highly uncertain world in which a smuggled nuclear bomb might be detonated in Paris or Manhattan."[16] Thus, preventing nuclear proliferation and nuclear terrorism has risen to the current administration's number one priority.[17] This has been following intermitted with the deterrence policy as demonstrated over the last 20 years. This expansion of the nuclear RMA to include terrorist use of nuclear weapons pushed the evolution of technologies for detection, identification, and information about all the current and possible future nuclear powered nations.

Dr. Andy Butfoy, an international security specialist from London, notes, that the nuclear RMA "encompassed the exploitation of many overlapping and mutually reinforcing factors – satellite technology, a communications revolution, breakthroughs in data processing, improved surveillance and target identification, stealth technology, increase weapons accuracy and range, and the magnified ability to rapidly focus firepower on selected targets."[18] By demonstrating the United States has the ability to project itself anywhere in the world in the first part of the twenty-first century in order to contain state actors; it maintains the status quo of the non-use of nuclear weapons.

## The Future

The future holds unknown threats, and according to the Nuclear Posture Review report, ("By working to reduce the salience of nuclear weapons in international affairs and moving step-by-step toward eliminating them, we can reverse the growing expectation that we are destined to live in a world with more nuclear-armed states, and decrease incentives for additional countries to hedge against an uncertain future by pursuing nuclear options of their own," p.vi.)[19] John Caves, a distinguished fellow at the National Defense University's Center for the Study of Weapons of Mass Destruction, observes, "Despite its call for the abolition of nuclear weapons, China is the only recognized nuclear weapons state that is both modernizing and expanding its nuclear forces."[20] This may bring the US back into another Cold War with a different country while still continuing limited warfare in other parts of the world. Even as the drawdown in Afghanistan occurs, the Defense budget outlook shown in Figure 1 still shows expenditures in excess of $600 billion through 2017. According to Caves, "The reality is that geopolitical developments actually could increase rather than decrease US dependence on nuclear weapons to deter and contain challenges from nuclear-armed great powers."[21]

## Conclusion

The continuation of deterrence only works if all nuclear parties (Russia, China, U.S., France, U.K., Pakistan, India, North Korea and possibly Israel)[22] accept that any one country in possession of an arsenal is willing to use it. According to Knox and Murray the issue with MRs and RMAs is sometimes the organizations that create them don't know they are doing so until a new one replaces them.[23] As the Cold War, the Global War on Terrorism, and the future threat have shown the world, nuclear weapons have shaped society and the State as well as how we organized and conduct 21st Century Warfare.

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# Benefits of Nuclear Survivability

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The Army has prepared itself to face nuclear threats since it built and used the world's first nuclear weapon in combat. Today, the Army requires that all mission critical systems with electronics be hardened against the nuclear weapon effect of High Altitude Electromagnetic Pulse (HEMP).[1] The HEMP survivability requirement is generally not challenged by Combat and Material Developers. From a threat standpoint, HEMP can be created by a state with relatively undeveloped nuclear and missile technology. A single nuclear weapon detonated at high altitude can generate a HEMP over a wide area.[2] In terms of hardening, dealing with HEMP is not unlike dealing with other electromagnetic environmental effects (E3), like lightning, directed energy weapons, and interference from friendly communications emitters and radars. If one is dealing with a set of E3, adding HEMP to the set is not costly or technologically challenging.

The Army also requires that mission critical weapons systems be hardened against a broader set of nuclear weapons effects.[3] This requirement is more frequently resisted by developers. It is a less obvious threat and is more difficult to harden against. The threat is less obvious because few states have tactical nuclear weapons. Since the collapse of the Soviet Union, there are no clear cut scenarios involving the use of nuclear weapons against deployed formations. When one does imagine a nuclear weapon being used against our forces, it is easier to imagine a response involving the United States responding in kind than continuing the conventional fight on the battlefield. Besides the threat being less obvious, hardening against it is difficult. One must deal with thermal radiation, nuclear blast, and initial nuclear radiation (INR). The INR environment is composed of neutrons and gamma rays, considering both dose rate and total dose, which affect electronics in different ways. Added to these challenges is the increasing pressure to save money in the face of significant budget cuts.

This article seeks to make clear the benefits of the Army's requirement to harden mission critical systems against thermal radiation, nuclear blast, and INR.

The nation's hedge against long-term uncertainty. Bradley Fighting Vehicles unloading in Pusan, Korea. These vehicles are currently being hardened to survive the effects of nuclear weapons at modest cost to the Army.[5]

**Strategic Benefits**

The benefits to the Army's nuclear hardness program extend beyond the survivability of individual systems. By sustaining the Army's nuclear survivability program, we dissuade adversary proliferation and sustain the technical knowledge associated with nuclear hardening. These are strategic benefits that exist regardless of whether any individual system is hardened. The key is maintaining the nuclear hardening requirements of enough systems through the lifecycle maintenance process to realize these strategic benefits.

To dissuade adversary proliferation, we must influence a potential nuclear weapon state's decision on whether or not to develop or otherwise acquire nuclear weapons.[4] There are significant costs associated with violating promises not to proliferate, such as international sanctions. As important as imposing costs is denying benefits. If a proliferating state is a potential adversary of the United States—a likely case—then it will see less benefit to possessing nuclear weapons if it knows that the U.S. Army is fully prepared to deal with nuclear weapons. If we field forces that are hardened to the effects of nuclear weapons, there is one less benefit to an adversary obtaining them. On the other hand, if we abandon our hardening program, we present the potential enemy with a softer target. This will be one more weight on the scale in his calculation of whether or not to obtain nuclear weapons.

One could plausibly argue that the hardness of U.S. Army combat systems

is not likely to be a significant driver in this decision. If one considers Iraq's on-and-off weapons program prior to 2003, it is difficult to imagine Saddam sitting in one of his palaces thinking, "I was going to develop nuclear weapons, but I heard that the Abrams is hardened so I won't." However, suppose that the U.S. Army had abandoned its policy of hardening its systems against nuclear weapons. Instead of thinking of the specific hardness level of a specific weapon, Saddam might have thought, "The U.S. Army thinks that nuclear weapons are too scary or difficult to deal with." This would have been a rational conclusion on his part and plausibly could have been a significant factor in his decision regarding nuclear weapons development.

The second strategic benefit is sustaining the technical knowledge base. The Army has been able to attract talented engineers and scientists to commit to a career based on knowledge of nuclear weapons effects. This technical knowledge base can be compared to a human body. It is mature and healthy. Its health can be sustained through modest effort and expense. If we allow it to die, it would be very difficult indeed to replace it with an infant. Worse, we cannot know when or for what purpose we will need this knowledge base. The Army would face a situation similar to that faced by the Air Force and Navy, which have not sustained the expertise necessary to maintain their strategic ballistic missiles to the point that, according to the Defense Science Board, "Current skills may not be able to cope with unanticipated failures requiring analysis, testing, and redesign."[6] By maintaining the nuclear hardness requirement and consistently applying it, we create a need for Material Developers who understand the impact of nuclear weapons effects on systems and the technical approaches for addressing those impacts. We create a need for Combat Developers to understand how nuclear weapons impact the forces they are developing. We create the need for parts suppliers to build radiation tolerant parts. Finally, we sustain our test facilities and their personnel.

As with dissuading adversary proliferation, rational arguments exist against maintaining the technical knowledge base. One could read through the list of people above who need to maintain nuclear knowledge and think that it could hardly be worth the cost. Conventional thought might suggest that cutting this initiative is a chance to accept a bit of risk and spend taxpayers' money on something more pressing. This might be true were it not for the modest cost of the Army's hardening program. Historically, meeting and sustaining a system's nuclear hardness requirements amounts to approximately 1% of total program costs. When one considers that there are only about fifty systems with a full nuclear survivability requirement, this is cheap. Consider how much the Army spends on big ticket programs that are cancelled prior to production. How much do they contribute to our long term security? If chopping out this modest spending is an opportunity to capture some short term savings, then sustaining it is a cheap way to mitigate long-term risk.

**Individual Program Benefits**

As noble a goal as achieving these strategic benefits might be, the Army spends money program by program and it is the individual Program Manager (PM) who must justify his costs. He might not be able to say, "I'm taking one for the team with my nuclear survivability program. Check out these strategic benefits in the *Combating WMD Journal* to which I'm contributing." He will need something relevant to his individual system to justify the costs involved. Fortunately, there are concrete benefits to an individual program and the soldiers who use the system.

The most important of these benefits is the preparedness against future threats. In their recent study of ground vehicle modernization in the U.S. Army and Marine Corps, Andrew Krepinevich and Eric Lindsey of the Center for Strategic and Budgetary Assessments identify the proliferation of nuclear weapons as one of seven trends impacting the future land warfare environment. They find that "[t]he ongoing proliferation of nuclear weapons and changing attitudes about their use will substantially increase the likelihood that U.S. military forces will confront an adversary that is willing and able to employ nuclear weapons."[7] Besides noting the increasing likelihood of a nuclear battlefield in the developing world, Krepinevich and Lindsey cite a published Central Intelligence Agency memorandum and Congressional testimony which point to Russian development of small yield nuclear weapons and more flexible employment doctrine.[8]

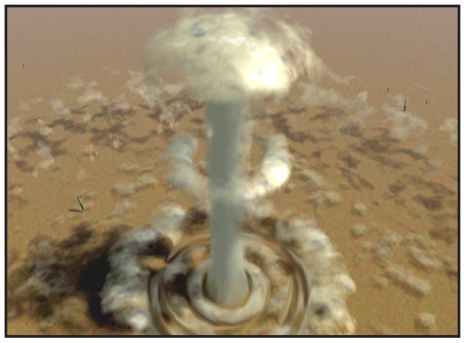
One might challenge the relevance of this assessment when discussing the Abrams and Bradley, since these are cases of matching legacy systems against hypothetical future threats. However, the Abrams and Bradley vehicles will be in service twenty-five years from now. Consider that twenty-five years ago Russia was a threat in its incarnation as the Soviet Union. If our relationship with Russia can change so dramatically in one twenty-five year period, can it not change again in the next twenty-five years? Who guarantees that Russia will be friendly? Alternatively, who guarantees that it will be orderly and its 12,000 nuclear warheads will be secure and accounted for?[9]

Another benefit to an individual program is that sustaining a system's nuclear hardness is much less expensive than trying to recreate it. Just as the technical knowledge of the Army as a whole is inexpensively maintained and cannot easily or quickly be recreated, so it is with the hardness of an individual vehicle. Currently, the essential parts of a hardened vehicle are tested on a supplier by supplier basis, the results captured in a database, fixes for faulty parts implemented, faulty parts tracked through the fleet of fielded systems, et cetera. In the case of the Abrams and Bradley, this management system has been developed

and improved over thirty years. If it is abandoned, knowledge of what parts from what suppliers are inherently hard goes away. Knowledge of how to fix faulty parts atrophies and then goes away. Knowledge of what parts are in what vehicles goes away. Knowledge of how to manage the databases that track this information atrophies and then goes away. Knowledge of how to test parts for radiation tolerance atrophies and then goes away. Surely the cost of recreating this system is an order of magnitude higher than sustaining it. If today's user doesn't want nuclear hardened vehicles, what about the user ten or fifteen years from now? If one justifies a modest savings using the requirements of today's user, one is setting up the future PM to spend a fortune meeting the possible needs of tomorrow's user.

A third system level benefit is that hardened systems deter enemy nuclear weapon use. Just as a hardening program throughout the Army impacts an adversary's decision on whether to develop nuclear weapons, a survivable formation impacts his decision to use them. In this case, the benefit is much more concrete. The impact of nuclear weapons on battlefield formations can be modeled with confidence. Currently, the Army hardens its systems to the level at which humans will survive on the battlefield. If we stop hardening our systems, the radius at which our formations are likely to be impacted by a nuclear weapon extends from the radius at which humans in vehicles are inherently vulnerable to the level at which electronics are disrupted. In very rough terms, this leads to a quadrupling of the area impacted. If an enemy can quadruple the area over which his nuclear weapon is effective, he is that much more likely to use it.

The final system level benefit of sustaining a full nuclear hardening program deals with soldier morale. Currently, combat vehicles are designed and built so that if the crew lives, their vehicle works. This is a consistent message that can be communicated to operators. Currently, soldiers can be told, "After the event, keep fighting," and "If you live, you still have a mission."[11] Lowering the level at which we harden vehicles complicates and sours this message. If some or all functions are left unhardened, the message to soldiers would need to be something along the lines of, "After the event, get your vehicle as close to the rally point as possible before you collapse so that we can repair it and give it to another crew," or "If the automotive system works but the fire control system doesn't, that means you are not going to be with us much longer."



Not the end of the world. Nuclear weapons are big bombs. Failing to harden our systems makes adversary nuclear weapons more effective than they otherwise would be.[10]

## Conclusion

The Army is facing tough decisions in the near future on how to accomplish its mission with a smaller budget. Naturally, all of our spending needs to be examined to ensure that we are not wasting increasingly scarce resources. But allow leaders make these decisions with eyes wide open. Any decision today to cut the Army's nuclear hardening program will present a large problem for future decision makers in the likely event that nuclear weapons become a steadily more serious threat.

## Author Biographical

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## End Notes


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2. *Report of the Commission to Assess the Threat of the United States from EMP Attack*, 2004, Vol.1, pp. 4-6.
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5. Source: dodlive.mil, accessed 17 February 2012.
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# Protection Factors of Combat Systems

COL Joseph F. Marquart
Mr. Joseph C. Nellis, Chemical Engineer
U.S. Army Nuclear and CWMD Agency

**Consider this plausible scenario:**

Unit Cmdr: "DragonToc, this is Recon6, be advised that the new vehicles and shelters just off-loaded from the bird (break). Troops are positioned and ready for movement in 15 mics. Over."

CP: "This is Dragon Toc, copy that , Recon6 (break). We prepared quadrant maps showing routes and locations for your mission…(break) …Transmitting them over right now…(break) Three circles on map refer to distances 5, 10, and 15 clicks from the center of radiation source. Over."

Unit Cmdr: "This is Recon6, maps showing up on our screen now… (break). Good job, men…(break) Now transmit PF values for our systems. Over."

CP: "This is DragonToc, be advised that for 2 days we tried to get PF values…(break)… PFs don't seem to exist for new systems (break). Found only a few for 2005 and older. Over."

Unit Cmdr: "This is Recon6, the plan included PF values for our vehicles. (break)… Be advised that without PFs we cannot move forward (break) (break).

(Long pause).

Unit Cmdr: "This is Recon6, (break) all units stand down and abort mission…(break). I say again, abort mission (break) and return to assembly area."

**Background and Problem Definition**

Protection Factor (PF) is a quantitative value of the vehicle's or the shelter's ability to shield occupants from penetrating nuclear radiation. The measurement of a particular shield to protect against incident radiation depends on its thickness, material composition, and the type and energy of incident radiation(s). The measure of radiation shielding is a ratio called the PF, defined as

$$PF = \frac{\text{Free-field radiation dose}}{\text{Dose of radiation penetrating the shield}}$$

The "free-field" radiation dose is the dose of radiation with no shield present. The protection factors are commonly expressed as ratios of dose rates instead of doses.

Currently, there is no DoD regulation requiring the Army to obtain radiation PF for combat vehicles and shelters. Previously, the PFs were measured only for a few selected vehicles and combat systems. Today's combat environment has changed to the point that accumulating PF data to fill this gap is prudent. To plan and execute missions in radiologically (R) contaminated environments, Commanders must know the PFs of their vehicles and shelters.

Based on recent lessons learned from Operation Tomodachi (Japan), where PFs were required to support operational decisions, the Army must address gaps to implement a requirement to measure PFs in systems which may operate in R-contaminated environments. Radiation exposure is a serious hazard to soldiers. Currently, ground component Commanders are hindered in making exposure decisions without established PF information on their systems.

Without PFs for combat vehicles and shelters, Commanders cannot determine the appropriate length of operational exposure in which their forces could safely operate in R-contaminated environments. The above scenario amplifies the importance of PF information.

**How to Solve this Gap**

USANCA is initiating a process for the Army to begin measuring PF on combat vehicles and shelters, particularly for mission critical systems. If a system is required to operate and protect the crew in an R-contaminated environment, knowing the PF is an extension of this operational requirement.

**Proposed Way Forward**

To put into motion the data collection effort, the Army will adopt the PF requirement. The means of gathering the valuable data is outlined below:

A near-term solution is to incorporate the requirement to collect PF data in the capability development documents (CDD) for combat systems. Initially, the Combat Developer (CBTDEV) would address PF in their requirements section of all CDDs for manned combat vehicles and shelters. During document staffing, USANCA verifies the PF statements for completeness, or suggests modifications to accommodate the system. (See a sample of PF statement in Table 1). The PF paragraph is tracked as a test requirement from the CDD to the Test Evaluation Master Plan (TEMP) and Detailed Test Plan. Consideration had been given to introduce this requirement with the system CBRN survivability criteria, but it is not practical since PF values are not criteria and will vary by system.

The long-term solution is the requirement for CBTDEVs to include a PF statement in all appropriate CDDs. The most appropriate guidance document is AR 71-9, Warfighting Capabilities Determination. Additionally, the PF testing requirement can be incorporated in the next revision of AR 73-1, Test and Evaluation Policy.

**Sample PF Statement for Use in Capability Documents**

During test and evaluation (T&E) of the system, the radiation protection factor (PF) will be measured and recorded. The system provides its occupants with shielding from penetrating radiation hazards. Commanders at all levels require the PF information to plan for, control, and manage the occupants risk during operations in radiologically-contaminated environments. For this reason, it is paramount that the radiation PF is measured and collected, especially for all armored vehicles. To operate in this type of contaminated environment, Commanders and users must know the PF to determine mission duration and make risk calculations.

Table 1. Sample PF Statement

**Courses of Action for Obtaining PF Data**

There are several ways to obtain the actual PF values on systems: (a) Direct measurement; (b) measurement of composite materials used in construction to estimate PF of systems; and (c) modeling. These approaches are outlined and analyzed below.

Direct Measurement. In this approach, the system is sent to the test site and the PF is directly measured using a radioactive source. An advantage to this approach is that it can be done concurrently with other test activity, and the cost is generally low. The tester is responsible to conduct a system level test and provide the data in a standardized format to the PM and USANCA. The PF value is addressed by the program manager (PM) in the Technical Manual for the system. The tester and PM are also responsible for transferring PF data into the Army's Testing Database System.

During T&E phase, the cost for direct measurement of PF will be addressed in the overall test program for the system, by the PM. Cost depends on complexity of the combat system. This is a relatively uncomplicated test based on Allied Engineering Publication-14 employing calibrated radiac meters and a radiation source such as cobalt. The PF data are collected and recorded with other test data. There is no need to develop a new scientific process to measure PF on a system level because it is already addressed in Test Operations Plan (TOP) 01-2-625. Additionally, with systems under development, the PF will be established at the end of the testing period in the acquisition life-cycle. Ultimately, PF values will be provided in the System Evaluation Test Report by Army Evaluation Command.

The direct measure for obtaining PF data is preferable because it is least costly and it is prompt. The PF values would then be readily available to Commanders, units, the community utilizing the test database, and USANCA. USANCA would be the repository of PF data for operational users and potential modeling scenarios.

Measurement of Composite Materials used in construction to estimate PF of systems. With this approach, the PFs of materials are measured and collected before assembly of military vehicles and shelters. PF data for composite materials can be collected and stored for later use estimating the PF of a new system. The advantage of this approach is that the PF values will be available for modeling or manipulation, and can be applied conceptually to any system in the future.

The disadvantage of this measurement is it requires significant upfront funding before the PFs of conceptual systems can be estimated. This approach does not include geometrical effects or any second order neutron effects.

M1114 Up-Armored HMMWV (photo by U.S. Army)

Modeling. Currently, only old codes are available for modeling PF data. These codes are based on obsolete equipment and do not meet AEP-14 requirements. In order to make modeling a viable option, new PF data are required to update the codes. After PF data are collected from direct measurement on actual systems or from composite materials, computer modeling could be introduced. The model provides radiation dose data affecting personnel inside the system. One of the benefits of coupling computer models to the data is that it allows averaging PF for all system orientations, since the direct measurements are only made at a few vehicle/shelter positions. Without such integration of computer models and experimental data, the applicability of resulting protection factors would be very limited.

While modeling would enhance PF measurements, it requires allocation of resources to improve existing models and the development of new codes to meet AEP-14 requirements. In addition to the expense of generating and validating new codes, further resources are required at regular intervals for ensuring maintenance of the special codes

**Conclusions**

It is important to record PF values for manned combat systems such as armored vehicles and shelters. A Commander needs this information for determining mission duration and calculating risk when operating in a radiation-contaminated environment.

Army stakeholders such as White Sands Missile Range, the Army Nuclear and Chemical Survivability Secretariat, and DTRA concluded that the most effective and affordable approach for implementing the PF requirement for new systems is instructing CBTDEVs to insert language into

CDDs. The new PF requirement is tracked in the TEMP and Detailed Test Plan. Eventually, the requirement must be addressed in regulations (AR 71-9 and AR 73-1).

The best approach for obtaining PFs for legacy systems is direct measurement while undergoing product improvement or retrofit.

The cost for measuring PF directly on systems depends on the complexity of the system. Cost for PF measurement would be borne by the PM as an integral part of the nuclear test program

The benefit in implementing the proposed PF measurements will address troop protection at relatively low cost. PF information will mitigate some costs of long-term effects associated with medical treatment of soldiers exposed to nuclear radiation.

STRYKER (Photo by Fotodynamics)

Mobile Tactical Shelter S-280C/G designed for housing communications and electronics equipment (Photo by U.S. Army)

Shelter, Tactical, Expandable, Two side (Photo by U.S. Army)

**Further Reading**


1. QSTAG 754 (AEP-14), Guidelines for the Armored Fighting Vehicle Designer to Improve Nuclear Radiation Protection (U), 17 Jun 1992. (classified report).

2. JP 3-12, Doctrine for Joint Nuclear Operations, Dec 1995.

3. FM 3-11.6, Multiservice Tactics, Techniques, and Procedures for Chemical, Biological, Radiological, and Nuclear Aspects of Command and Control, MCRP 3-37.B, NTTP 3-11.34, AFTTP (I) 3-20.70, Sept 2007.

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