

Combating WMD **JOURNAL**

U. S. Army Nuclear and CWMD Agency

Issue 5 Spring/Summer 2010

Sea Power - Deterrence From The Sea

The U.S. Nuclear Weapons Accident & Incident Program in Europe

The Mission that Drove World History

USANCA Launches Army CWMD Information Portal (ACIP)

Historical Development of the Nuclear Weapons Accident Response Procedures

Making Foreign Consequence Management Harder

Pandemics of the Past: A Learning Opportunity

*The Need to Redefine Electromagnetic (EM) Protection:
"A Think Piece"*

*Nuclear Power Plants on Military Installations:
"A Think Piece"*

Defining Weapons of Mass Destruction

*Nuclear Medical Science Officers:
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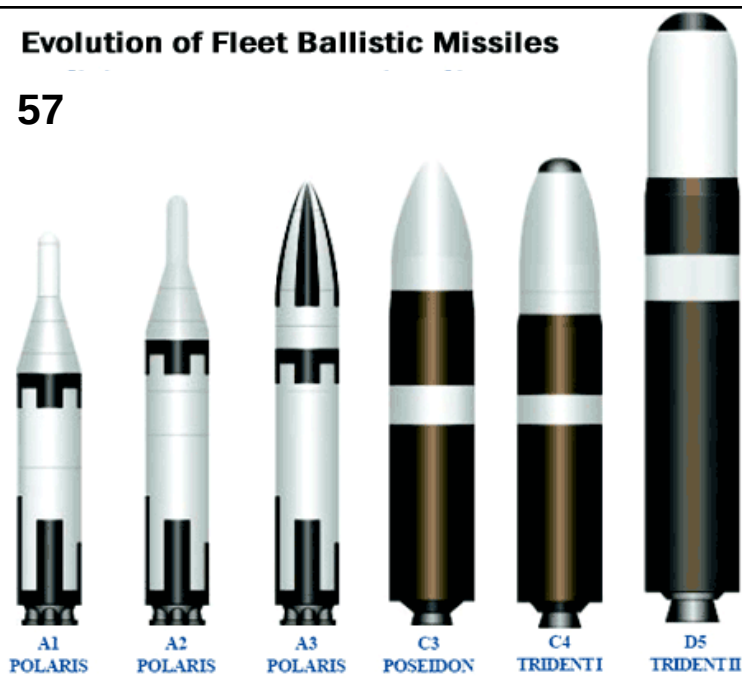
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FROM THE DIRECTOR

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

result it has been an incredibly busy time.

One area that is immediately recognizable is the expanded requirements for a Standing Joint Task Force-Elimination. Currently it is unclear what the headquarters will look like and what its span of authority will be, however, the 20th Support Command (CBRNE) will continue to play the predominant Army role in support of the elimination missions. To that end the 20th is expanding their capacity with the addition of Nuclear Disablement Teams (NDT) to support OCONUS contingency operations. And the NDT's are in turn expanding mission profiles to include an increasing number of WMD Coordination Elements (WCE) to provide broader support to all geographic AORs. With the recent transformation of the Technical Escort Battalions, this provides the Army with the capacity to operate more efficiently and globally, providing support to the War, and preparing for additional contingencies within the ARFORGEN model.

This is both an exciting and critical time for the Army's combating WMD community. Over the last few months the Executive Branch has released several key policy documents including the Quadrennial Defense Review, the Nuclear Posture Review, and the National Security Strategy. Each of these documents has significant impact and influence on how the Army plans to train and equip the force. Furthermore, the documents provide guidance and insight into how the government intends to execute future missions. Imbedded in these seminal documents are "specified" or "implied" requirements. USANCA and the Army Staff are taking an aggressive approach ensuring that the correct Army agency or command is integrated into the development of strategic options. As a

Further developments are happening in Homeland Defense. The CBRNE Consequence Management Response Force (CCMRF) concept is currently being revisited and analyzed. Options being proposed by USNORTHCOM will require Army readiness to meet future WMD Consequence Management requirements domestically, while at the same time supporting the Army goal to reach the optimal ARFORGEN cycle of 1:3. Within the Joint Community there is lengthy discussion of the requirements for an emerging Foreign Consequence Management (FCM) mission. The recent response to the Haiti earthquake has created some interesting data points regarding force flow and response times. This experience is informing the ongoing discussion on FCM and assisting in shaping the re-

quirements.

Nuclear weapons (or indeed any WMD) in the hands of terrorists remains the greatest threat to our national security. And while the only effective way to Combat WMD is a “whole of the government” solution, the simple fact is that the Army will do the heavy lifting. USANCA and the Army Staff work daily with FORSCOM, TRADOC, and the Joint Community to ensure we are the best prepared and are the best fit for any task in the eight CWMD mission areas. Under the current constraints, it is becoming more important to ensure our friends, allies and partners are also poised to meet these mission challenges with internal domestic forces. The primary way to accomplish this is through shaping combined exercises to increase and improve partner capabilities.

Over the last six months, several senior leader tabletop exercises (TTX) occurred that discussed many of the CWMD 8 mission areas. The outputs from most of the TTX-determined that if we build partnership capacity (BPC) we will be well positioned to meet our national security objectives. That is easier said than done. In few cases do partner nations overtly engage in combating WMD, particularly without a perceived problem. However, our partners certainly should collaborate on issues that are of a direct concern to them. The solution is to find those crosscutting operational and tactical “tasks” that meet both CWMD and non-WMD challenges. Ongoing programs with the Defense Threat Reduction Agency, Department of State, Department of Energy and others use this approach.

To develop innovative and enduring solutions, the next Army CWMD Synchronization Conference (14-16 September 2010) will develop a range of potential Phase 0 shaping tasks. The conferees will develop intermediate objectives or those tasks that build the “desired effects” which meet the military strategic objectives. Simply put, if we can determine what twenty, thirty, or forty training events that must occur at the strategic, operational and tactical level, then we can begin to build “packages” to meet the ASCC requirements. I expect over the

next several months to determine what engagement tools or events are common to all the ASCCs. I will have USANCA then look for Army and Joint resources to build training teams.

Within the Army structure there is an ongoing program executed by the USA Corps of Engineers (USACE). The Civil-Military Emergency Preparedness (CMEP) program has been active globally for years and has a record of successful engagement. While USACE will continue to execute the program oversight has been transferred to USANCA, where I expect CMEP to become an umbrella program not only covering traditional natural disasters, but WMD CM, Health Affairs, Narcotics, and other transnational threats. Using CMEP with a wide-angle lens we can build “plug and play” events that meet cross cutting goals and objectives. This is just one way that the Army can efficiently and effectively build our own capacity to meet our Phase 0 shaping requirements.

Therefore as you prepare for this year’s Army CWMD Synchronization Conference I’d ask that you think about Phase 0 requirements in your AOR, or how your organization can assist in closing gaps. Our conference end state will contribute immensely towards shaping the Army’s strategy for the next few years.



Defining Weapons of Mass Destruction

LTC Randy G. Masten

Department of Joint, Interagency, and Multinational Operations
US Army Command & General Staff College

Hostile states and non-state actors in possession of WMD represent significant security challenges. Some states, including supporters of terrorism, already possess WMD and are seeking even greater capabilities, as tools of coercion and intimidation. Joint Publication (JP) ¹

According to JP 3-40, *Combating Weapons of Mass Destruction*, "The primary challenges facing the joint force commander (JFC) are: the diversity of threat actors, including the emergence of nontraditional WMD threats; the varied nature of WMD demands a varied approach to deterrence; a complex WMD proliferation continuum; the dual-use nature of much of the related technology and expertise; and the increasing complexity and number of WMD proliferation networks." ² So, what exactly are WMD? JP 3-40 defines WMD as "Chemical, biological, radiological, or nuclear weapons capable of a high order of destruction or causing mass casualties..." ³ While the definition fits the mental model that most people have of WMD, this article will show it is not the definitive or singular definition provided within Joint or Army doctrine.

The phrase "weapons of mass destruction" has evolved into a wonderfully elastic term that can be stretched to include all forms of nuclear, biological, and chemical (NBC) agents. The definition for WMD tends to expand and contract to better fit the needs or agenda of the individual or group employing the term. In the past decade, the phrase has developed such a flexible meaning that the term WMD is currently too broad and



Pablo Picasso, *Guernica*, oil on canvas, 1937 Reina Sofia National Museum, Madrid. *Guernica* shows the tragedies of war and the suffering it inflicts upon individuals, particularly innocent civilians.

no longer suffices to meet the needs of the Department of Defense (DOD) or interagency environment. As the name implies, weapons of mass destruction should be limited to a category of weapon systems and munitions that are intentionally designed with the capability of inflicting a catastrophic degree of death or destruction upon its intended target.

Currently the Army and other Services do not have doctrines for combating WMD. As each Service develops its doctrine for combating WMD, they need to have a common definition from which to base their doctrine. If the definition of WMD remains overly broad, there is a risk of crying wolf for every use of a chemical or biological weapon. In order for the services to focus on real world, major threats a clear, consistent, and common definition of WMD must be accepted by the DOD and all of the Services. This paper will review a few of the many current definitions for WMD and offer a common definition to be

adopted by the Army and its Sister Services.

Evolution of the Term WMD

The phrase WMD originated out of the increasingly industrialized and mechanized battlefields of Europe in the years preceding World War II. The first published account of the term was made on 28 December 1937 in a *London Times* article describing atrocities in the Spanish Civil War. Cosmo Gordon Lang, Archbishop of Canterbury, proclaimed in a sermon "Who can think without horror of what another widespread war would mean, waged as it would be with all the new weapons of mass destruction." ⁴ This reference to WMD was made with regard to Germany's aerial bombardment of the city of Guernica, the continued employment of chemical weapons, and the use of other advanced armaments during the Spanish Civil War. Following World War II, the United Nations (UN) adopted the term WMD and

added atomic weapons to the definition, while at the same time condemning their use around the world.⁵ WMD were defined in 1948 by the UN Commission for Conventional Armaments as those which include “atomic explosive weapons, radioactive material weapons, lethal chemical and biological weapons, and any weapons developed in the future which have characteristics comparable in destructive effect to those of the atomic bomb or other weapons mentioned above.”⁶ This definition, while flawed, continues to guide international disarmament diplomacy and applies to international law, given the use of the term in several arms control treaties.

Over the course of the next five decades, the common definition of WMD continued to morph. During the 1950’s, the term became synonymous with nuclear weapons and remained so throughout the era of MAD (mutual assured destruction). Later, during the 1970s, the term came to include biological and chemical weapons as well. It wasn’t until the end of the decade that WMD came to include a virtually unconstrained number of weapons. The United States Code, Title 18, *Crimes and Criminal Procedure*, currently defines WMD as:

- (A) *any destructive device* as defined in Section 921 of this title; [Section 921’s definition includes grenades, mines, missiles with an incendiary or explosive charge of more than one-quarter ounce, and rockets with a propellant charge of more than four ounces.]⁷
- (B) *any weapon* that is designed or intended to cause death or seriously bodily injury through the release, dissemination, or impact of toxic or poisonous chemicals, or their precursors;
- (C) *any weapon* involving a disease organism; or
- (D) *any weapon* that is designed to release radiation or radioactivity at a level dangerous to human life⁸

The decision to include *any*

weapon containing nuclear, biological, or chemical agents as a WMD has brought about the following equation: **NBC = WMD**. According to the Nuclear Threat Initiative⁹ “the most widely used definition of weapons of mass destruction in official US documents is nuclear, chemical, and biological weapons.”¹⁰ One example can be found in the 2006 *National Strategy to Combat Weapons of Mass Destruction*. Its opening sentence clearly illustrates this point: “Weapons of mass destruction (WMD) – nuclear, biological, and chemical – in the possession of hostile states and terrorists represent one of the greatest security challenges facing the United States.”¹¹

The 2004 *National Military Strategy* (NMS) definition of WMD adds “enhanced high explosive weapons (E)” and “other more asymmetrical weapons” to the WMD equation, thereby creating WMD/E. The acronym WMD/E is often used interchangeably with CBRNE (chemical, biological, radiological, nuclear, and enhanced high explosives).¹² The issue here is that another ill-defined term “enhanced high explosives” has been added onto the end of the already confused term WMD. Additionally, no definition is provided for the phrase “other more asymmetrical weapons.” Instead of avoiding this poorly defined terminology, the February 2010 Quadrennial Defense Report (QDR) uses both WMD and CBRNE; while not providing a definition for either term.¹³

The 2004 NMS definition of WMD further adds to the confusion by including weapons capable of causing *mass disruption*. This represents a dramatic departure from earlier definitions:

WMD/E includes chemical, biological, radiological, nuclear, and enhanced high explosive weapons as well as other, more asymmetrical “weapons”. They may rely more on disruptive impact than destructive kinetic effects. *For example, cyber attacks on US commercial information systems or attacks against transportation net-*

works may have a greater economic or psychological effect than a relatively small release of a lethal agent.”¹⁴

The 2004 NMS expanded the definition for WMD to include cyber-weapons that are not designed, nor capable, of causing mass destruction. These weapons are capable of causing a mass disruption in society and producing mass effects upon their intended targets, but they lack the ability to produce a large number of casualties. Therefore, these weapons should be categorized as *weapons of mass effect* (WME). The cyber-attack examples in the NMS definition are not intended to bring about a high degree of destruction to people or a nation’s physical infrastructure. Instead, these cyber-attacks affect a system or systems in order to produce a high degree of disruption. If destruction were to occur, it would be a secondary or tertiary effect and not the primary intent of the cyber-weapon. An example of this would be a software coder that writes a line of code into a software program that enables power plants to control their electrical flow. If the malicious code was properly hidden and self-launched on all user systems at the same date and time, the potential affect would be a complete loss of power to millions of electrical power users and the wide-spread disruption of US economic, governmental, and societal activities. The first order effect of such an attack would be mass disruption; while there are some obvious secondary/tertiary cascading orders-of-effect that can propagate from the initial target of the attack, they would not be the primary goal of the attack. This type of cyber-attack can be classified as a WME, but it does not constitute the use of a weapon of mass destruction. A WME is designed to be symbolic or to cause financial, psychological, and political damage against their targets, more so than to cause physical destruction.

However, an item not specifically addressed in the NMS definition is a cyber-weapon with the capability, intent, and inherent design, to cause mass destruction. An example of this type of weapon would be a code spe-

cifically designed to cause mass destruction, such as by successfully targeting a pesticide factory. In this example, a cyber-weapon would target a factory using chemicals in the production of many pesticides. The code would cause chemicals to be routed into water storage tanks, rather than into its own containers. The resultant reaction could cause a toxic gas cloud to form and be released into the surrounding environment. This scenario would replicate the disaster that occurred at a Union Carbide facility in Bhopal, India on 23 December 1984, when human error, not a cyber-weapon, caused the formation of a toxic gas cloud. The incident in Bhopal killed more than 2,500 people and injured more than 400,000.¹⁵ The profound environmental effects of this disaster are still felt today in Bhopal.¹⁶ Would such a cyber-weapon be classified as a WMD, as its primary intent would be to cause mass destruction and death?

Ambiguity Surrounding WMD

As a result of the confusion surrounding the definition of WMD, examples of how the term WMD can be misapplied are found with relative ease. For instance, the Monterey Institute of International Studies maintains the Monterey WMD Terrorism Database, which monitors open-source information regarding the use of WMD. "The database includes more than 1,100 incidents - from 1900 to the present - that relate to the use of CBRN materials as possible weapons."¹⁷ MIIS is a well-respected academic institution and its WMD Terrorism Database is maintained through US government funding. The database tracks any CBRN agents which have been, or have attempted to be, employed against a human target. The use of a CBRN agent directly constituted the use of a WMD regardless of its design or capability for causing destruction. Thus the database is filled with WMD terrorist events that include the use of such common chemicals as battery acid, hydrochloric acid, chlorine gas, pepper spray, to name a few. While these events may constitute the use of a chemical agent as a weapon,

once described they hardly meet the threshold for mass destruction.

If the use of any nuclear, biological, or chemical agent against a person/place can be construed as a use of WMD, then Georgy Markov was assassinated by a WMD in the middle of London in 1978. Mr. Markov was a Bulgarian dissident living in England, whose assassin (allegedly the KGB) used an umbrella gun to fire a single microscopic projectile containing Ricin poison into Mr. Markov's leg, which subsequently resulted in his death.¹⁸ In this incident, a chemical agent was used, it was weaponized, and it caused the destruction of a living target. This weapon clearly lacked "mass" by the nature of its design and intent, as it was only capable of killing a single individual; however, under several current definitions used within the Department of Defense, this could be classified as a WMD attack.¹⁹

Definition and Criteria for WMD

The term weapon of mass destruction means any weapon or device that is intended, or has the capability, to cause death or serious bodily injury to a significant number of people through the release, dissemination, or impact of

- (A) toxic or poisonous chemicals or their precursors;
- (B) a disease organism; or
- (C) radiation or radioactivity.

U.S. Code Title 50, Ch. 40, Sect. 2302 *War and National Defense Definitions*

The United States military is tasked with defending our Nation against attacks and threats posed by WMD. "The highest priority of the US military is to defend the Nation from all enemies."²⁰ If combating WMD is a stated objective for our military forces, then it is incumbent upon the leadership to ensure that WMD exists as a clearly defined and consistent term in our military doctrine and policies. Additionally, our allies and enemies alike clearly understand what our government means when it uses the term WMD. Thus, the term is left open to exaggeration or downplay.

Supreme Court Justice Potter Stewart's Casablanca Test of "I know it when I see it," will not stand up to international or domestic scrutiny. If the term WMD can include almost every weapon, then its meaning is too broad to be of use in military doctrine.

An excellent case can be made to avoid the use of the term WMD in military doctrine, as the term has become overly broad and is now commonly used as a convenient catch phrase for nuclear, biological, and/or chemical weapons. The term was originally developed for diplomatic dialogue to facilitate multilateral disarmament talks. And, the term WMD has remained relatively consistent in meaning within the international disarmament arena. WMD would be best left to the lexicon of the disarmament negotiators and treaties; however, the term is now so prevalent that this is not a probable solution to the problem at hand. "The horse has left the barn," so to say.

Currently, it is not feasible to remove the term WMD from military doctrine. Therefore, the term needs to have a standardized and consistent definition within military doctrine. The criteria for determining if a weapon can be considered to be a WMD should be based on design, intent, and capability. In order to be considered to be a WMD, the weapon should meet all three of the following criteria:

1. Design: The agent is weaponized, (i.e., it exists as a weapon system comprised of the agent and a delivery vehicle).
2. Intent: The weapon system is manufactured or created with the intent to cause large-scale destruction of life and/or infrastructure. Does not include unintended or unpredictable second and third order effects of the weapon's use.
3. Capability: The weapon system has the ability to cause large-scale destruction through a single release, not the cumulative affect of the employment of multiple weapons (bombardment).

This definition and its set of criteria will prevent a WME or CBRNE attack from officially being classified as a

WMD attack. It will also serve to separate chemical and biological munitions from WMD in planning campaigns or operations against a potential enemy. Under this proposed definition a Sarin-tipped mortar round would not be considered to be a WMD, nor would anthrax-laced letters. While both would clearly violate either Article I of the Chemical Weapons Convention or Article I of the Biological Weapons Convention, they would not be classified as WMD, as they lack the capability for mass destruction.

Conclusion

In the military profession, as in the legal realm, words have meaning. They are used to convey specific thoughts and ideas and should be chosen accordingly. The term WMD is used throughout the most recent NSS, NMS, and QDR with each offering its own definition for WMD. The US has gone to war over the threats posed by WMD, yet it has not provided the military, its allies, or its enemies with a consistent definition for these weapons systems. Planners and policymakers must agree upon a definition that does not exaggerate or downplay the capacity for destruction that is present in the weapons possessed by potential enemies. To do so, is a grave disservice to the United States and those sworn to protect and defend against her.

The proposed use of definition of WMD provided in Title 50 of the US Code breaks the strict NBC = WMD paradigm and provides a more consistent definition for these threats. The intent is not to diminish the threats posed by NBC or CBRNE, but to keep their capability for destruction in perspective. To claim that an improvised explosive device (IED) laced with a pesticide is a WMD is to exaggerate its destructive capability and potentially cause an undue level of anxiety among our ground troops.

While at the same time, the risk of diminishing the actual threat posed by a weapon capable of mass destruction is likely. If virtually every threat on the battlefield can be deemed to be a WMD, the soldier may come to

view them with less concern than they rightly deserve. All CBRNE weapons and IEDs should be regarded as grave threats to human life; however, the term WMD should be reserved for those weapons that are capable of producing a large-scale catastrophic event.



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ENDNOTES

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8. United States Code, Title 18, Section 2332a, Chapter 113B, 5 January 2009.
9. The Nuclear Threat Initiative (NTI) is a non-profit organization with a

mission to strengthen global security by reducing the risk of use and preventing the spread of nuclear, biological and chemical weapons.

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19. Ricin is a potent cytotoxin that can be derived from the seeds of the Castor plant and is one of the most toxic known substances.
20. *Quadrennial Defense Review Report*, 18.

The U.S. Nuclear Weapons Accident & Incident Program in Europe

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A U.S. C-17 GlobeMaster carrying United States (U.S.) nuclear weapons over Europe crashes after an in-flight emergency. The crash kills the crew resulting in “loss of custody” for the weapons. The weapons break apart and burn on impact. Confusion reigns. Was this a terrorist act? Is there a radioactive hazard to the public? What measures should first responders take? Is a nuclear explosion possible? While this scenario may be improbable, there have been U.S. nuclear weapons accidents in Europe. A U.S. Air Force B-52 broke apart in a refueling accident over Palomares, Spain in 1966 strewn four nuclear bombs on the ground and in the water. The conventional explosives in two of the bombs exploded scattering radioactive material from the nuclear components. The U.S. excavated and sent over 1400 tons of contaminated soil to the Savannah River Plant and site monitoring is still in effect today. As late as 2004, the U.S. Government paid for decontamination efforts. If a nuclear weapons accident happened tomorrow, the affected governments and the U.S. would focus intensely on the accident response.

The 1957 North Atlantic Council Communiqué established stocks of nuclear weapons in the North Atlantic Treaty Organization (NATO) and the 2009 Strasbourg Declaration on Alliance Security stated deterrence was a core element of NATO’s strategy and based on an appropriate mix of nuclear and conventional capabilities. While the Alliance reduced its nuclear forces drastically during the last 20 years and President Obama seeks a world free from nuclear weapons, at



least in the short term, U.S. weapons will remain in Europe during the disarmament stage.

US Nuclear Accidents & Incidents on Foreign Soil

How would we respond to this accident? A nuclear weapon accident response is complicated in the U.S. with multiple agencies and overlapping authorities. Overseas, it faces additional complexities. Foreign nations have primary consequence management responsibility even for U.S. nuclear weapon accidents. The U.S. needs to respect nations’ sovereignty, preserve U.S. custody of nuclear weapons, and mitigate the accident consequences.

Incorporating a large U.S. multi-agency response into a large multi-agency foreign response (and potentially several countries) is challenging.

The Department of State (DOS) addresses this complexity by negotiating Nuclear Accident & Incident (NAI) Agreements to clarify roles and to develop an effective response capability in the unlikely event of a U.S. nuclear weapons accident. DOS is the U.S. lead federal agency and coordinates the U.S. whole government response for overseas nuclear weapon accidents. U.S. European Command (EUCOM) is responsible for the military part of the response and tasks components to provide a Response Task Force (RTF) for a nuclear weapon accident. A general officer commands the US Air Forces in Europe (USAFE) RTF and reports directly to the EUCOM Commander. EUCOM and USAFE develop Implementing Joint Operational Plans (IJOPs) with the necessary operational detail for the RTF under the umbrella of the DOS agreements. These plans are an integration of U.S. and foreign emergency management plans.

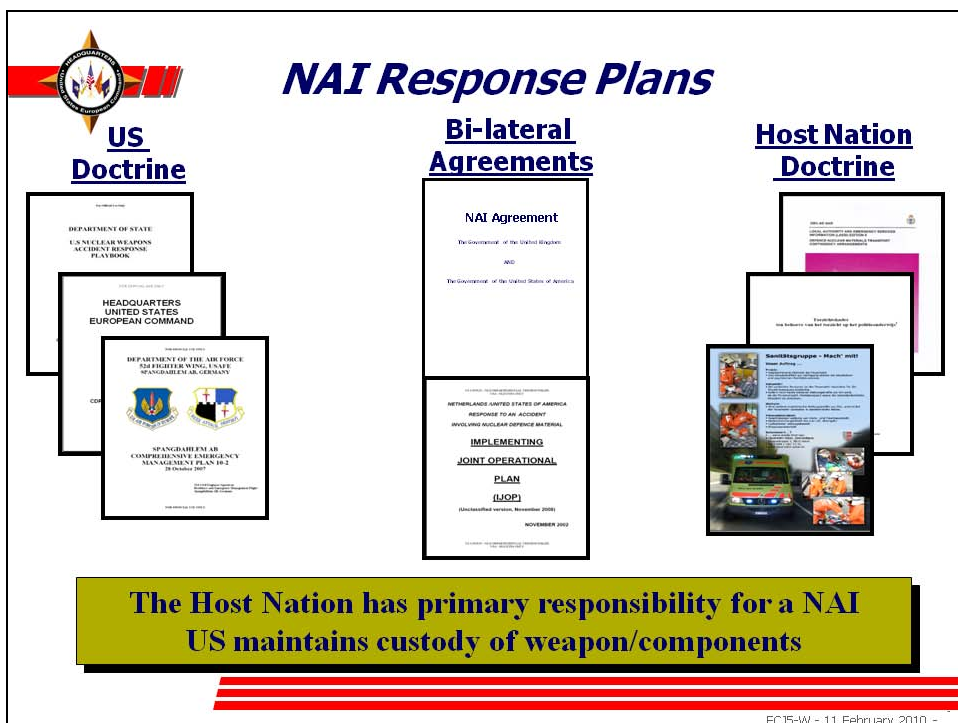
The problem is these agreements and IJOPs do not always exist. After 9/11, there was a renewed interest in NAI agreements. Often non-nuclear disasters or mishaps have motivated the US and other countries to focus on NAI programs, whether it’s a large fireworks factory disaster or simply an aircraft containing an official US Embassy mail pouch over-running the runway. National emergency management systems enable effective, collaborative incident management, but these disasters highlight short-

comings. In 2002 and 2005, DOS approached several nations about developing NAI agreements and protocols. However, no agreements were concluded.

This resistance exists on both the U.S. and foreign sides. There are concerns about classifications and political repercussions, “Can we even discuss this with the nations?” “Can we even write this article?” A joint U.S. – foreign nation nuclear accident response program is often deemed too sensitive. This hypersensitivity stems from the perception that the existence of a plan equates to the confirmed presence of US nuclear weapons in that country. The existence of a joint NAI program with a specific country does not mean that the U.S. has weapons within that country. Since NATO’s nuclear capable units may require the transport of U.S. nuclear weapons within the theater, the NAI program focuses on plans to deal with the possible accident consequences. EUCOM addresses questions about the locations of U.S. nuclear weapons with the U.S. “No Confirm, No Deny” policy, then turns the discussion back to the fundamentals of accident response. Keeping accident response separate from political questions downplays the sensitivity of NAI response

Support exists for accident response planning independent of positions about nuclear weapons. For example, after a military aircraft crash in 2009, a Green Party representative from Germany, Ulrike Höfken, called for joint NAI exercises with the military, fire, police and rescue services.¹ Based on the Green Party stand against nuclear weapons, one might think a Green Party representative would not encourage joint nuclear weapons accident exercises, however, all parties realize preparing for this high risk, low probability event is prudent.

A U.S. NAI is similar to other sensitive disaster scenarios nations deal with every day: power plant radiation emissions, rail accidents with toxic materials shipments and aircraft accidents. EUCOM’s experience with foreign nation emergency manage-



ment representatives is that they approach a NAI in the same professional manner. A NAI program for securing and mitigating an accident has spill-over benefits, since required actions are similar to other joint efforts.

The Department of State - European Command Approach

But how can you effectively minimize the accident aftermath, which requires joint planning and preparation without the foundation of agreements and IJOPs? Arthur Ashe’s words come to mind, “Start where you are. Use what you have. Do what you can.” The inability to progress on NAI agreements caused a rethinking of the approach - moving away from national agreements and focusing on developing actual response capabilities. In 2007, the National Security Presidential Directive 28 Committee of Principals supported this new direction with the DOS “Playbook” as the first manifestation. The DOS Foreign Consequence Management program developed the “Playbook” to give the U.S. Embassies a checklist for responding to U.S. nuclear weapons accidents. In early 2008, DOS and EUCOM hosted a seminar to introduce this new concept. There are three main points:

1. Integrate Embassy, RTF and foreign nations into training, rehearsals and exercises. While recognizing the legal importance of agreements, EUCOM has focused on integrating all of the players into NAI training, movement planning and exercises, utilizing core mil-to-mil connections as the starting point. Civilian ministries and agencies would lead the response to a U.S. NAI. By integrating training, U.S. organizations gain an appreciation for the national response capabilities; while the foreign nation organizations learn about U.S. response capabilities and the designed safety features of U.S. nuclear weapons (Enhanced Nuclear Design Safety, improved High Explosives, etc). The U.S. has designed its nuclear weapons to withstand the most severe accident without a nuclear yield or release of radioactive contamination, but many do not know that a nuclear explosion in an accident is virtually impossible. The U.S. and foreign emergency management exchanges allows them to scope the problem and take appropriate actions in a nuclear accident. This grass roots approach builds capacity in the absence of formal agreements.
2. Develop capability through existing military coordination structures. The integration of each nation’s response system and the U.S. system

is bi-lateral. The NATO Allied Command Operations Directive 80-6 specifically refers to NAI response as a bi-lateral responsibility. However, EUCOM uses forums like the NATO Joint Theatre Surety Management Group (JTSMG) to address many nuclear issues in a broader framework. EUCOM leverages these structures to allow countries with less developed programs develop a more robust capability by observing nations with more advanced programs.

3. Develop “European” NAI response academic material. Most U.S. guidance focuses primarily on U.S. response operations. Logically, The Defense Threat Reduction Agency (DTRA) based its training on this US model and often used concepts such as declaring a U.S. National Defense Area around a NAI site. Many of these methods are simply not applicable in Europe. Upon completion of the first round of NAI Response training, EUCOM asked the DTRA Director to revamp its NAI training program to better reflect the overseas response environment. Since then, DTRA has begun providing invaluable support to multiple initiatives: It modified the RTF training to focus on unique European requirements; is developing an annual European NAI exercise; and will facilitate the upcoming European NAI Senior Leaders Seminar. This article discusses the impacts of these changes later. In addition to DTRA’s academic efforts, EUCOM is sponsoring a NATO School course and it assists nations in developing their own internal Fire Academy training courses.

Building Response Capability

EUCOM developed an overarching NAI program to support foreign nation, U.S., and joint requirements for a functional NAI program. The following paragraphs discuss the senior leader, academics, bi-lateral, training & exercises, and movement segments.

Senior Leader Programs

The Department of Defense (DoD) and DTRA host a NAI Senior Leader Seminar every year to provide train-

	Joint	Host Nation	US - Only
Leadership	RTF Senior Leaders Conf (1 day)		
Academics	Joint US-HN NAI Course (1 week) NATO School NAI Course (1 week)	US/HN Site Training (1 day)	Firefighting Training (1 day) RTF Cdr Executive Session (1/2 day)
Exercises	NAI Annual Exercise (1-2 days)		Combined RTF TTX (1 day)
Movements	3 AF Type I/II Rehearsals (2-4 x 1/2 day)	Notifications Teams Stand-by	
Bi-Lateral Mtgs	◆ ◆ ◆		

Nuclear Accident & Incident (NAI) Program.

ing to senior leaders. This seminar addresses the interaction between State, Federal, DoD, and Department of Energy (DOE) agencies for a U.S. nuclear weapons accident within the United States. This seminar does not focus on a U.S. NAI overseas where the DOS and the nations play a critical role. The DOS and EUCOM are hosting the European NAI Senior Leader Seminar in 2010 to provide a similar overseas forum for high level discussions. The seminar will include senior Embassy officials, Ministry of Defense officials, Department of Energy Senior Energy Officials, U.S. RTF Commanders, U.S. Initial Response Force Commanders, the EUCOM Plans & Policy Director and the FBI. The Third Air Force Vice Commander will be the seminar facilitator with DTRA providing seminar support. This meeting ensures a common understanding of the US overseas response.

In addition, USAFE, DTRA and EUCOM developed a joint executive session to brief senior leaders on the NAI program. This provides an opportunity to brief new RTF commanders, Embassy officials and general officers about the EUCOM NAI program.

Bi-lateral Meetings

Most nuclear accident planning is bi-lateral by nature, so bi-lateral meetings serve a critical role. The

Netherlands – United States Standing Operations Group (NUSOG) is a bi-lateral group that meets regularly to discuss procedures, education and engagement programs. Multiple agencies, across a range of functional areas, from both the foreign and U.S. governments attend these conferences. Dutch members come from the Ministry of the Interior, Defense, Environment, Transportation, Explosive Ordnance, Fire, Police and Rescue agencies. U.S. members include the U.S. Embassy, EUCOM, DTRA, USAFE, Munitions Support Squadron, various wings and Third Air Force. The NUSOG has seven functional areas, each with a U.S. and foreign national lead responsible to address specific functional area issues.

Academics

Nuclear weapons accident response incorporates many different organizations. This requires various academic programs to reach all the training audiences.

- RTF Training: USAFE, DTRA and EUCOM restarted on-site training in 2007 for all US nuclear response elements. This training lasts one day and improves NAI response at all levels of command. The mobile training team (MTT) conducts the sessions on a regular cycle. USAFE and EUCOM coordinate the schedule



Academic work at the Defense Nuclear Weapons School, Albuquerque, NM.

and invite DOS and local military and civilian authorities as subject matter experts and members of the training audience. In one example, the United Kingdom (UK) Nuclear Accident Response Organization instructed and participated in training in March 2009. Their expert provided de-

tails on specific national capabilities that raised the course training value. DTRA provides course materials and facilitators and helps develop "European" NAI response academic material. In the future, DTRA plans to modify the MTT material to specifically address each nation

emergency response structure.

- **U.S. /Foreign Nation NAI Course:** This is a week-long comprehensive joint U.S. -Foreign Nation courses for educating civilian and military personnel. EUCOM plans to tailor these courses for each nation. The NUSOG developed the first joint NAI course. Functional experts in the NUSOG developed the course segments. As part of the preparation, the Dutch sponsored instructors from the Defense Nuclear Weapons School (DNWS) to travel to Europe to review The Netherlands response organization and procedures. These instructors helped to develop the course curriculum through interviews with Dutch and U.S. personnel.

The NUSOG held the first iteration of the course at DNWS in October 2009 in Albuquerque, NM with 26 Dutch and 19 U.S. participants. Participants came from a variety of organizations: The Netherlands' Ministries of Interior, Defense, Housing Spatial Planning and the Environment, Transport Public Works and Water Management, Royal Netherlands Air Force, Municipalities, Regional Firefighters, Hazardous Materials personnel, National Crisis Centre, Air Staff, Department of Energy, DOS, EUCOM, USAFE, Third Air Force, Air Force Major Operating Bases, Munitions Support Squadrons and DTRA. The course had a series of table top exercises integrating all functional areas and levels of response, as well as intense mock media interviews. In keeping with the multi-lateral approach, the NUSOG invited other nations to observe the training and reported the results of the seminar to the JTSMG.

- **NATO NAI Course:** Using the NUSOG course as a base, the nations, DTRA and EUCOM are creating a generic NATO NAI course. A NATO course allows personnel from several countries to attend and better understand the scope of an NAI response. The first course will be in December 2010 at the NATO School in



The Netherlands-United States Standing Operations Group (NUSOG) emblem.



Dimming Sun 03, UK MCA Command Post.

Oberammergau, Germany. Instructors will include foreign nationals, the Department of Energy, the Embassy, DTRA, EUCOM and USAFE.

- Firefighting Instructions: Since many of the first responders to a

NAI are civilians, EUCOM works with national organizations to develop unclassified firefighting instructions. Without prior exposure to nuclear weapon accident hazards, first responders arriving on scene are unlikely to know how to minimize contami-

nation and safeguard public health. It is better that firefighters learn what protective gear is adequate during an academic session, not under the stress of putting out a fire. The nations provide these instructions, but the U.S. provides technical advice and assists in development.



Firefighters are usually the first responders to a NAI.

Joint NAI Exercises

In addition to academics, accident response exercises are crucial to solidify NAI programs. DIMMING SUN 03 in the UK, was one of the largest overseas NAI exercises. There were also several DIAMOND FLIGHT exercises in the Netherlands. EUCOM invited four Dutch to attend a U.S. NAI exercise in Wyoming in 2006. In 2008, the NUSOG proposed to include multi-lateral observers to bilateral NAI exercises to share lessons learned. This model is not unprecedented within Europe. EUCOM initially briefed the concept of multi-lateral participation at the JTSMG and in December 2009, The Netherlands presented a voluntary annual rotating joint NAI exercise to the JTSMG. In May 2010, The UK is hosting the first

such exercise, ASTRAL BEND that includes a joint UK-US seminar at RAF Mildenhall. The UK Ministry of Defence invited other national representatives to attend this exercise as observers. An overview of the exercise will be given to the JTSMG. Next year, a joint US-Dutch integrated exercise is scheduled with other bi-lateral exercises lining up for subsequent years.

Other types of exercises include DOS table top exercises at the embassies to practice NAI procedures. The last such exercise was in July 2009 with the US Embassy in The Hague, The Netherlands. EUCOM and DTRA also attended a Belgium military aircraft crash exercise. EUCOM and the nations can use the lessons learned from these exercises to integrate a U.S. presence at accident sites.

Movements and Foreign Disclosure Information

Transportation Command Tanker Airlift Control Center provides notifications to the U.S. Embassy for movements. The Embassy then coordinates overflight approval with the nation and response capability is placed on stand-by. After the movements are coordinated, Third Air Force conducts rehearsal of concept drills. These rehearsals address any specific considerations for the upcoming movement and foreign representatives are included to ensure better coordination. Including these representatives has been helpful, but not without growing pains. The Foreign Disclosure Office (FDO) clears movement information prior to release to other nations because of its sensitive nature. In one instance, the FDO approval came one day after the movement rehearsal, so the representative could not attend the actual briefing. Instead, USAFE held a special "make-up" briefing two days later. Since then, Third Air Force FDO is clearing a template of the information for a smoother, quicker clearance process.

To confidently discuss and release information to our allies is critical for the NAI program. EUCOM regularly



clears training program information through the FDO. In the move from a strictly bi-lateral approach to a more multi-national approach, EUCOM has worked with partners to ease bi-lateral restrictions. This allows formerly bi-lateral only information to be disclosed on a multi-lateral basis. In most cases, this was easier than supposed because most accident response information is unclassified. Early on in the NAI process, the FDOs within the DOE and DoD expended a considerable effort to determine exactly what information about weapon design safety the U.S. could release and at what classification levels. Proper classification ensures civilians without security clearances can access the information they need to do their jobs.

NAI Public Affairs

Because of the safety design characteristics of nuclear weapons, any actual radiological contamination is expected to be relatively minor; however, the public affairs aspect of an accident is a difficult facet. In addition, while "No Confirm, No Deny" is the standing policy, there is an exception for a nuclear accident, "During a nuclear weapon accident overseas. . . the theater Commander. . . with concurrence of the foreign government through the appropriate Chief of U.S. Mission, may confirm the presence of nuclear weapons or radioactive nuclear components in the interest of public safety." ² This disclosure may occur with just the public perception of a hazard -- even when no actual radiological hazard exists; both gov-

ernments can immediately confirm the presence of a nuclear weapon, if it promotes public safety. With modern communications, having a coordinated public affairs strategy is important.

In contrast to the U.S. public affairs policy, the French have an open, active public affairs policy toward nuclear weapons. The French are free to confirm nuclear weapons locations and this gives them more latitude in their public affairs strategies, to include active public education campaigns on the consequences of a nuclear weapons accident. EUCOM was able to compare strategies at a French NAI public affairs conference in 2009 sponsored by the Office of the Secretary of Defense.

Nuclear Accident & Incident Policy

A number of NAI response policies shape the US Government NAI program in Europe. The DoD Instruction 3150.08 "DoD Response to U.S. Nuclear Weapon Incidents" summarizes key overseas policies:

- A Nuclear Weapons Accident / Incident Exercise (NUWAIX) program shall test annually DoD consequence management capabilities to respond to a U.S. nuclear weapon accident in foreign nations.
- DTRA shall provide training and exercise support to EUCOM and the Response Task Forces. DTRA shall coordinate the training curriculum to remain consistent with the EUCOM Contingency Plan 4367 "Response to U.S. Nuclear Weapon Accident / Incident within the Theater."
- The Secretary of the Air Force shall provide funding to ensure RTF operational capabilities and participation in the NUWAIX program.
- The EUCOM Commander shall coordinate response actions with the Chief of Mission in each affected country and conduct an 18-month NUWAIX



UK Decontamination tents.

training cycle for headquarters staffs and RTF. Agreements with the participating nations in consultation with DOS govern the scope and scheduling of exercises.

The Office of the Secretary of Defense (OUSD Policy Nuclear Matters) has worked closely to support the EUCOM NAI program. They have attended numerous conferences and meetings. At the request of the Office of the Secretary of Defense, EUCOM briefed the European NAI program in October 2009 to the Nuclear Weapons Accident Incident Response Subcommittee of the Nuclear Command and Control System Committee of Principals Deputies to keep them updated. EUCOM updated the Subcommittee again in February 2010.

Nuclear Accident Plans

As the operational headquarters, Third Air Force is responsible for the NAI response operational plan. Third Air Force is hosting an extended Operational Planning Team with representatives invited from various response locations to address RTF operational procedures and country specific actions, timelines, personnel and equipment variations in the Third Air Force base plan. Several factors make it more difficult to develop a coherent RTF plan. Third Air Force forms the RTF only after an accident

occurs and the RTF consists of several geographically separated units: Third Air Force headquarters, an initial response force from the closest major USAFE installation to the accident, a Munitions Support Squadron and the DOE Accident Response Group; the RTF engages other specialty teams, as needed. NAI response is only a small part of these units' overall mission; each unit is only a small portion of the RTF; and they must know how to operate in different foreign national emergency response systems. This makes it difficult to coordinate an integrated U.S. response.

Summary

Planning and preparing for a possible NAI in Europe presents unique challenges that require an integrated approach from multiple agencies. EUCOM works closely with both U.S. and foreign departments and agencies. While foreign nations have the primary response capability, because of the sensitive nature of nuclear weapons and U.S. technical expertise, it is critical to ensure any U.S. input flows smoothly into the national response. Where agreements and IJOPs are in place, EUCOM works closely with US and foreign agencies to ensure close coordination. Where formal agreements do not exist, EUCOM uses practical coordination pro-

cedures and leverages existing military structures in a multi-lateral approach to develop a more robust response capacity. If a transport vehicle crashes, the Nuclear Accident/ Incident program will ensure a fluid response that protects public health and mitigates the consequences.

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ENDNOTES

1. Rhein-Zeitung, Wednesday, March 25, 2009, "Schleudersitz rettet Piloten in letzter Sekunde" p.7.
2. DoD Directive 5230.16, "Nuclear Accident and Incident Public Affairs Guidance", November 21, 2003

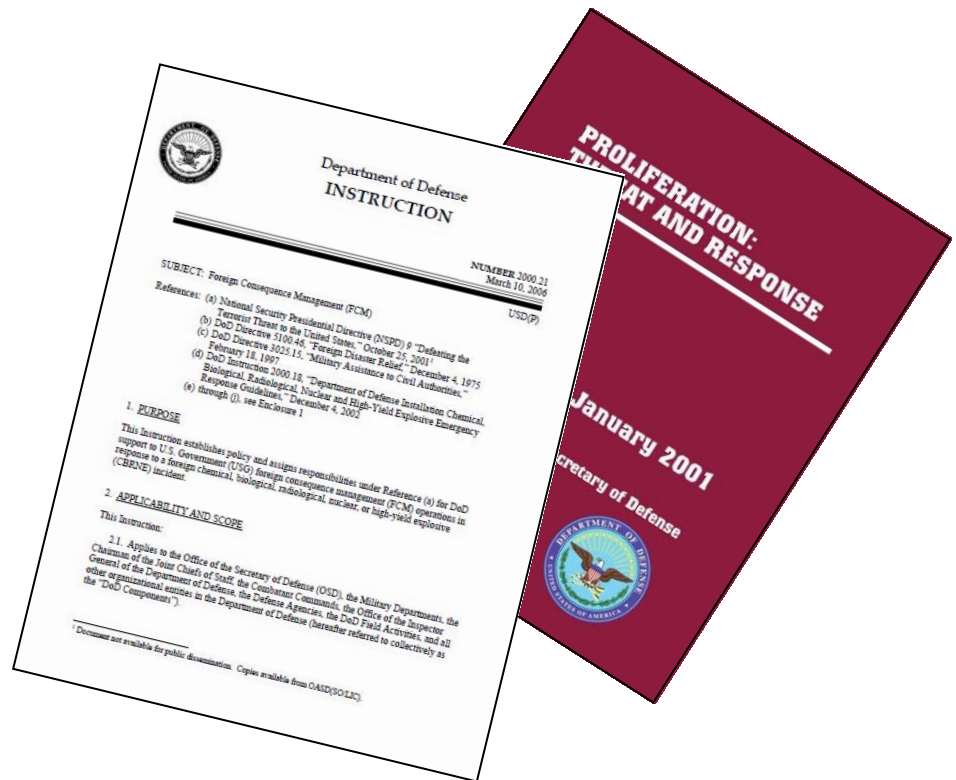
Making Foreign Consequence Management Harder

Al Mauroni
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Over the past eight years, the U.S. military's capability to support the federal response to a terrorist incident involving a weapon of mass destruction (WMD) has stumbled forward in a mad sort of dance – two steps forward, one step to the side, and one step back. It is often assumed that any terrorist incident involving any significant amount of chemical, biological, radiological, or nuclear (CBRN) material will automatically require support from the Department of Defense (DOD) to manage its consequences. The DOD's development of a WMD consequence management capability has been complicated by a number of factors.

There is the question of who the U.S. military is supporting: domestic state and local governments, foreign governments, or military installation commanders. The threat ranges from CBRN hazards and high-yield explosives to natural disasters and industrial accidents. U.S. military response capabilities range from technical advisors and specialized technical units to traditional support forces such as military police, engineers, and logisticians. The U.S. military has been told to plan for multiple simultaneous large-scale WMD incidents, single catastrophic events such as 9/11, and small-scale releases of industrial hazards. Debate continues on how quickly the U.S. military must arrive at the incident scene: within the first "golden hour" after the incident, within 48 hours, or within five days.

The challenge is that those DOD agencies engaged in developing consequence management capabilities are just saying "yes" to all of these questions without qualifying how to build and resource this mission. That's just not a responsible way to assist federal agencies that plan for, prepare for, respond to and recover



from terrorist CBRN incidents. As a result of the inability to untangle the Gordian knot, efforts to develop consequence management capabilities have been made much harder than it needs to be. Like many public policy issues, the development of military capabilities to respond to terrorist CBRN incidents has evolved over time in an incremental fashion, but has not been evaluated as a whole against contemporary challenges as to whether this capability is still appropriate or, in fact, requires change.

Consequence management includes those actions required to protect public health and safety, restore essential government services, and provide emergency relief from the hazards associated with a natural disaster, industrial accident, or terrorist incident. Originally, Presidential Decision Directive-39 directed the DOD in 1995 to support crisis and consequence management with

"technical operations." DOD had also viewed consequence management as a capability that would be required to restore operations at US military installations and facilities following a major combat operation that featured nuclear, biological, or chemical weapons. The purpose of consequence management is not to prevent an attack or save lives, but rather to restore essential services and to return a contaminated area to pre-incident conditions.

Building a Domestic Consequence Management Capability

Before 2001, domestic consequence management was a simple concept. DOD had technical experts who provided an expert capability that the federal, state, and local emergency responders lacked. The Army's Technical Escort Unit provided technical advice and limited support to emergency responders prior to and

during an incident. The Marine Corps' Chemical/Biological Incident Response Force (CBIRF) helped state/local emergency responders assess and clean up the hazard after the incident. Because of Aum Shinrikyo's 1995 sarin nerve agent attack in Tokyo, DOD was directed to train the emergency responders in 120 cities on chemical and biological terrorism response and to develop its Reserve and National Guard forces to support such responses. Defense Secretary William Cohen approved the WMD Civil Support Team concept in 1998 as a way to quickly provide subject matter experts to state and local emergency responders. The dedicated manpower was low and the cost of this technical support was insignificant, compared to other major defense priorities (and that's the way DOD wanted it).

After 2001, assumptions were that terrorists would use CBRN materials to cause simultaneous mass casualty incidents at multiple cities. There was limited rationale behind the assumption. It was more of an uninformed gut feeling that this is what terrorists in general would do, based on one particular terrorist group's practice of coordinating high-explosive incidents and the operational use of airplanes as mass-casualty weapons. As a result, Congress pressured DOD to accelerate its fielding and accreditation of 55 WMD Civil Support Teams. Government officials considered whether DOD should lead – rather than support – any federal response to a terrorist CBRN incident. The stated goal was that DOD should be able to provide the capability to respond to up to three multiple and simultaneous WMD mass casualty events. Actually developing that capability was a controversial issue, one that would be debated for several years.

When the Department of Homeland Security (DHS) was established in 2003, one of its first actions was to address the possibility of biological terrorism under the Homeland Security Presidential Directive-10, "Biodefense for the 21st Century." In 2005, DHS formed the Domestic Nuclear Detection Office to develop

means to identify the illicit movement of radiological and nuclear materials into the United States. Senior US government officials have stated on more than one occasion that chemical terrorism is not a significant enough threat that would require a massive federal response. In 2007, DHS began implementing guidelines for strict oversight of security at certain chemical facilities.

Despite these initiatives and the very generous DHS state/local grants program addressing CBRN terrorism preparations, DOD continued its efforts to build larger and more specialized units to support DHS in any response to CBRN terrorism. In addition to the civil support teams, the National Guard Bureau has planned to field seventeen CBRNE Emergency Response Force Packages – at about 160 persons each – and DOD plans to create three CBRNE Consequence Management Response Forces, each one fielding between 4000-5000 personnel. The Army organized its chemical specialty units and explosive ordnance disposal units into the 20th Support Command (CBRNE), stationed at Aberdeen Proving Ground, Maryland, to respond to terrorist incidents and to support national special security events (among other missions).

Now in 1995, this robust DOD response force might be seen as justified. The 2001 Amerithrax incident certainly fanned the flames of desire for a rapidly deployable and large group of technical specialists that could deliver a full range of emergency response capabilities. It might seem that only the military could provide such a capability. But today, given the lack of any identified specific foreign terrorist "WMD" threat, the high demands of operational combat missions, and the enhanced capabilities of federal and state law enforcement, emergency responders, and the intelligence community, one has to wonder if – given the chance to design a military WMD consequence management capability – this huge investment of personnel and material would be the optimal design that DOD would propose today. Such academic pondering is irrelevant, as

political realities would prevent any significant change of the current military units designated to support domestic response.

The Mission Outside the United States

As difficult as the domestic consequence management mission is to understand and implement, the DOD mission to develop and sustain a foreign consequence management capability is even harder to explain. Foreign consequence management includes assistance provided by the United States to another nation to regain essential government services and to mitigate the effects of a terrorist CBRN incident. Beyond that, it is unclear what the exact scope of the requirement is, what the authorities are, what resources are required, what the definition of "timely response" is, and – most importantly – who ought to budget for the training and sustaining of dedicated forces conducting foreign consequence management. The only thing that is very clear is that the State Department controls the authorization process by which US military forces provide foreign consequence management capabilities to other nations.

This mission should not be confused with the combatant commands' requirement to organize and control a joint task force for consequence management during traditional (conventional) military combat operations. If coalition forces are fighting another nation armed with CB weapons, there is clear guidance that the combatant command is to organize consequence management forces to assist those states who might be attacked by CB weapons over the course of that conflict. This mission should not to be confused with humanitarian assistance/disaster relief, which addresses those efforts to alleviate human suffering or to contribute to regional security or stability through deliberate planning (humanitarian assistance) or immediate response (disaster relief). In addition to the unique technical characteristics of CBRN hazards, the focus of consequence management is on restoring the essential services of a

government – not saving lives or alleviating human suffering. If there is no government that requests US support, it is not consequence management.

This focus on definitional clarity may seem overstated, but the need for it becomes clear when one sees the continuous debates and redefinitions of consequence management within DOD (let alone interagency discussions) every year. There is little consistency in what the mission is and who is responsible for addressing it, and as a result, there is little progress on developing a consistent and sustainable capability. Yet there has been no OSD policy leadership to resolve this basic issue of defining the mission and establishing the parameters for developing the capability.

There is the scenario where a US military installation or facility in an overseas location is hit by a terrorist CBRN hazard. Who responds to such an event? Is it solely the installation commander's responsibility to coordinate recovery efforts by coordinating within his or her service? Is it the host nation's responsibility to respond? Or is the US military (as a whole) expected to provide a capability, either in theater or deployable to that theater, to restore essential services and mitigate the consequences of this unique hazard? The answer is "yes" to all.

The installation commander is responsible to protect all of the workers and residents within the area of responsibility, to include implementing antiterrorism measures to protect against CBRN terrorism. However, because there is a very low probability that such an incident might happen and because antiterrorism funding is limited, there are often no significant antiterrorism measures designed for CBRN terrorism or resources inherent to the installation to support consequence management. The services in general are reluctant to preposition the significant logistics required for the mission and would probably turn to private contractors to provide post-incident response capabilities.

The host nation response will be varied, depending on its inherent response capabilities, the extent of its specialized forces' training, the resources available to address this threat, and of course, prior planning and agreements with local and regional US forces. It probably is safe to say that most nations do not have significant resources on a per capita basis as compared to the United States, but host nations do have the authority to respond to terrorist incidents and do know how to address incidents involving industrial chemicals, radiological hazards, and high-yield explosives. In many cases, such as Europe, nations work together and with international organizations to respond to biological outbreaks and nuclear accidents. It may very well be that these nations will not require U.S. government assistance for most terrorist CBRN incidents.

Still, there are those who believe that the combatant commands must have either an in-theater consequence management force or a rapidly-deployable joint task force to provide this capability. Some reference the vastly overstated assumptions and consequences in the fifteen Homeland Security Planning Scenarios as rationale and basis for developing forces for foreign consequence management. These worst-case scenarios were not meant for budgeting resources; decisions based on these scenarios would demand significant numbers of personnel and material to be dedicated to the very low probability of a terrorist CBRN incident. No service wants to commit to this concept when the national defense priorities are to support military combat operations in Iraq and Afghanistan and defend the homeland from attack.

An alternative solution requires that laws and regulations addressing the mission and roles of domestic consequence management forces be altered to enable these forces to deploy in support of foreign consequence management missions. This concept proposes a "global" consequence management force posture with centralized management. However, since each nation has a unique

set of capabilities toward specific threats, this joint task force would have to be prepared to execute a broad range of emergency response tasks with respect to all possible CBRN hazards. Dedicating a joint task force to execute missions on call both within and outside of the United States could be costly, and, in all likelihood, would still be unable to deploy to a foreign incident site within 96 hours of the event. In addition, taking domestic consequence management forces away from the states and local responders might elicit some significant political displeasure at the potential vulnerability caused by their deployment.

Some will argue that the Army's 20th Support Command (CBRNE) already wrestles with the challenge of addressing the demands of responding to domestic terrorism, supporting conventional military operations, and addressing WMD interdiction and elimination tasks. However, the 20th can not task National Guard units and is not designed to respond to no-notice overseas terrorist CBRN incidents. One might also argue that it is ill-prepared to do so, lacking both the necessary authorities and resources to adequately execute the mission – and it is highly unlikely that it would receive either in the near future. These are not inconsequential issues.

Changing the Mind-Set

The way out of this dilemma requires changes in perceiving the threat and organizing an acceptable response. We need to stop using worst-case scenarios – and in particular, the 10-kiloton nuclear terrorist incident – as the basis for planning DOD's manpower and resourcing requirements. There is no other area of defense policy where this type of worst-case scenario planning is supported. Violent extremist groups and insurgents in particular are not receiving WMD materials and technology from nation-states. They are improvising with available materials, using drums of volatile industrial chemicals, small amounts of toxins, and radiological material for dirty bombs. Their goal is not to overthrow Western civilization; it is to weaken the govern-

ment's authority and to influence the local populace, enabling their freedom to execute specific and limited organizational goals and objectives. Accordingly, we need to accept that a massive US military task force will not be required for the overwhelming majority of foreign consequence management responses, short of an active conflict with a WMD-armed state.

The National Military Strategy to Combat WMD proposes a framework that was originally designed to counter the actions of adversarial nation-states armed with CB weapons. It was not intended to be a homeland defense/civil support strategy, and in fact, DOD has developed a separate document detailing its homeland defense/civil support strategy. It was not (initially) intended to address the US military's response to the threat of adversarial nuclear weapons. We need to recognize those facts and embrace the difference between strategies intended to deter nation states with WMD programs and those intended to stop terrorists with CBRN material. There is a world of difference between those two communities, and loosely using the term "WMD" does not help to develop the right capabilities.

Conclusions

Domestic consequence management is a sacred cow requiring careful address. In an ideal situation, DOD would re-assess and re-assign those forces to a more practical and sustainable size, working with DHS and other government agencies to provide technical advice and cooperation in any required response scenario. We have to accept the politics surrounding this area and the nature of incremental policy direction. But at the same time, we should abandon ideas of using domestic consequence management forces for foreign consequence management missions. It's not executable, for legal, political, logistical, and financial reasons.

DOD does need to adapt to the language that DHS and the inter-agency uses – that is to say, the U.S. government doesn't use the terms "crisis management" and

"consequence management," but rather prefers the more holistic term "incident management." Using this term would, at the least, limit arguments over whether particular DOD forces ought to be supporting the crisis phase or the consequence phase or both. It would also more clearly support interagency discussions if all parties were to use common terms and frameworks regarding the complicated framework of organizing federal response to catastrophic incidents. If the US government truly believes in a "whole-of-government" approach, it must enforce a common lexicon for all federal agencies.

The DOD foreign consequence management capability should be limited to an advisory role. During the previous administration, there was a focus on "building partnership capabilities" for CBRN defense and consequence management. This should continue. It is not practical to dedicate US forces in overseas theaters or to develop a standing joint task force within the United States for the sole purpose of foreign consequence management. DOD can, however, provide technical advisor teams to those nations wishing to build up their incident response capabilities, and develop a technical "reach-back" capability to support any US military operational response. The services and combatant commands need to cooperatively develop plans for each overseas installation, plans that are shaped to the constraints and capabilities of each host nation. This will require the addition of a few dedicated CBRN defense experts to the combatant command staffs (expertise that is sorely lacking right now).

Military and civilian leadership view the threat of nation-state WMD programs and terrorist CBRN incidents as real, but manageable. Other defense priorities will continue to prevail over the issue of how DOD should respond to domestic and foreign consequence management. It truly is a case of if, not when terrorists will develop and use a WMD within the United States or against a US military installation overseas. If we are to develop a practical and sustainable foreign consequence man-

agement capability, these key principles must be clearly understood. If DOD leaders believed that a terrorist CBRN incident was imminent and the effects would be catastrophic, one would not see these mid-level action officers debating concepts, personnel, and funding. The keys to success include using realistic threat scenarios, adopting a common lexicon with interagency partners, and considering international capabilities while maintaining technical experts in key staff positions (in particular, augmenting combatant command staffs) and in deployable teams to assist federal, state, local, and international emergency responders.



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Pandemics of the Past: A Learning Opportunity

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Introduction

In April of 2009, newscasts from Mexico proclaimed that hundreds of Mexicans were ill with an influenza virus which was later identified to be "Swine Flu." Reports abounded about a significant number of deaths and a large number of infected people. The disease quickly began to spread across international borders, with confirmed infections in the United States (U.S.), United Kingdom (UK), New Zealand, Spain, Germany, and China. The Centers for Disease Control (CDC) and Prevention and the World Health Organization (WHO) mounted a phenomenal campaign to educate people regarding "Swine Flu," and the more appropriate moniker of "H1N1 Influenza Type A" slowly began to replace the term "Swine Flu." The disease was found in almost every state within the U.S. within several weeks of the initial infection. A sort of hysteria broke out regarding the deadly implications of "Swine Flu," or "H1N1 Influenza Type A." The mass media prompted many to stay home, not spread the disease, and see a doctor if you showed signs and symptoms of the flu; the most important symptom was dizziness, which normally does not occur with other strains of influenza. However, despite the media hype, the disease caused far fewer deaths and initial infections than many had predicted; the vast majority of those who were confirmed to have H1N1 Influenza A recovered.

This article will explore the following: What is the criterion for an epidemic or pandemic? What are the key differences between the two terms? What is influenza? How does it infect populations? Have there been other epidemics or pandemics



in the past from which we can learn? What conclusions can we draw from the past? Did the CDC and the WHO take the right steps to limit the swine influenza pandemic of April and May of 2009?

Epidemic versus Pandemic

The term, "epidemic," is a word whose origin lies with Greek: "epi + demos," meaning "Upon people."¹ An epidemic, is therefore, a disease that remains in a limited geographic region, but may be widespread among the population of that region. The term, "pandemic," is a word of Greek origin also: "pan + demos," which means "all people." A pandemic is not isolated to a geographic region; the disease spreads far and wide, encompassing entire countries, continents, and possibly the world.²

Many people commonly mistake the meanings of the two words; epidemics are confined to geographical areas, whereas pandemics are widespread.

Types of Influenza

There are three major types of

influenza, categorized by the suffixes A, B, and C. Influenza A is the type found in humans and many other mammals, including birds. Influenza A viruses have given rise to major epidemics and pandemics in both human and mammal/avian populations. Influenza B is nearly endemic to humans and it is far less common than Influenza A. It is occasionally found in populations of seals and ferrets. The genetic properties of Influenza B and its extremely limited host species preclude it from propagating a pandemic in humans. Influenza C is found in humans, dogs, and swine. It is also far less common than Influenza A, but it can produce virulent epidemics and extensive individual illness. Strains of influenza are categorized according to two major surface proteins: hemagglutinin, denoted by Hx, where "x" is an integer, and neuraminidase, denoted by Ny, where "y" is an integer. To date, medical science has identified sixteen distinct varieties of hemagglutinin and nine distinct varieties of neuraminidase found in influenza A. As an example, both Spanish Influenza and Swine Influenza are categorized as H1N1 Influenza A. Because Spanish Influenza and Swine influenza share similar typing, the Center for Disease Control and Prevention and the World Health Organization both issued strong statements in the early days of the most recent pandemic. The diseases are structurally similar in major respects, but there are subtle genetic differences which identify them as either Spanish or Swine Influenza.³

Medical science has a system that codifies influenzas using genetic coding. An example of how influenza is categorized is shown in figure 1.

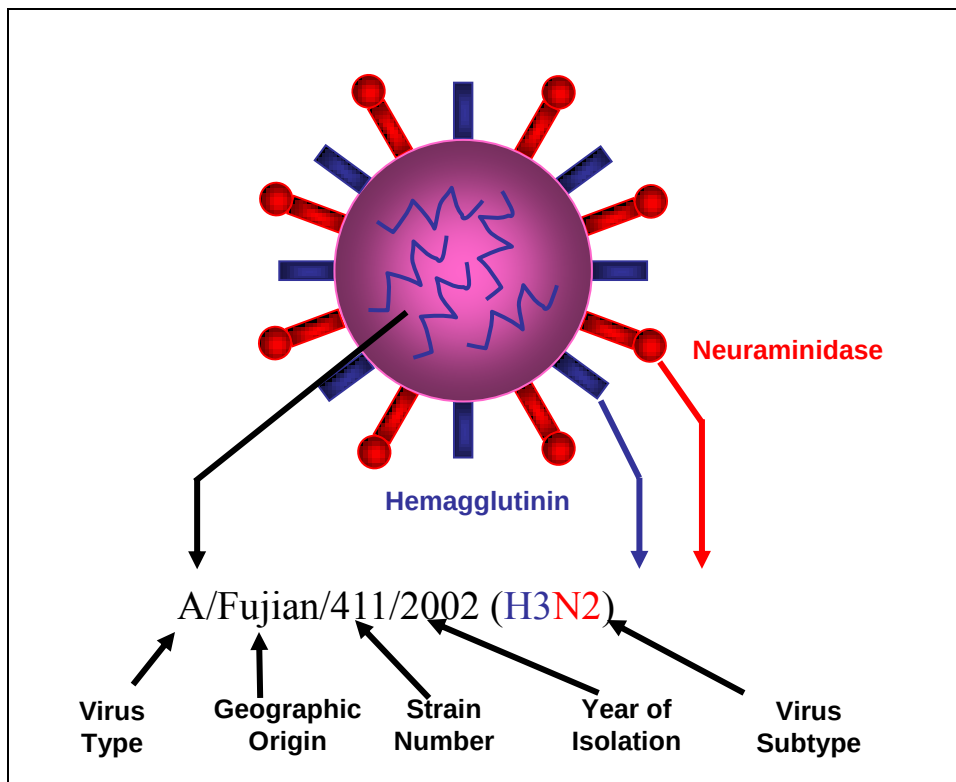


Figure 1. Categorizing Influenza.

Infection by and Replication of Influenza

Hemagglutinin is a protein that causes cells to agglutinate, or clump together, close to the virus. Hemagglutinin on the surface allows the influenza virus to attach itself to epithelial cells found in the throat, nose and lungs of mammals (and the intestines of birds); the virus then fractures sialic acid sugars and penetrates the cell membrane. The hemagglutinin shell of the virus breaks open through a process called endocytosis, releasing the interior contents of the virus into the host cell's cytoplasm. The viral proteins and RNA are then transported into the host cell's nucleus, where they begin to "reprogram" the host cell's nucleus to create a copy (or more likely several copies) of the virus. Once these copies are made, the replicated viruses are transported to the Golgi bodies of the cell and, once released, bind to the interior cell membrane of the host cell. The neuraminidase proteins break down the sialic acids of the host cell's cell membrane, allowing the new viruses to exit the host cell. The cell dies after the cell membrane is ruptured from the interior. Drugs now exist to

combat either the action of the hemagglutinin protein interaction with possible host cells (also known as M2 inhibitors) or the action of neuraminidase to release new viruses. Examples of M2 inhibitors are amantadine and rimantadine; neuraminidase inhibitors include such trademarked drugs as Tamiflu (oseltamivir) and Relenza (zanamivir). Each drug is effective in preventing a number of different strains of influenza, but none of the drugs is effective in dealing with all known Hx/Ny combinations and types of influenza.⁴

History of Influenza Pandemics

There have been many epidemics and pandemics throughout the history of mankind. With regards to influenza, a number of pandemics were recorded in the 20th century. The most notable were the Spanish Influenza (also known as H1N1 Influenza Type A) of 1918, which now stands as the most important and widely studied pandemic; the Asian Influenza of 1957 (also known as H2N2 Influenza Type A); the Hong Kong Influenza of 1968 (also known as H3N2 Influenza Type A); and the Russian Influenza of 1977 (debatable

as a pandemic, since it affected children only). Other notable epidemics were the Swine Influenza of 1976 and the Avian Influenza of 1997.⁵ Each pandemic is examined in some detail below.

Spanish Influenza of 1918

The Spanish Influenza Pandemic of 1918 infected approximately twenty to forty percent of the world's population, eventually killing around twenty to one hundred million people worldwide, depending on the source. Although exact figures are unknown, current evidence suggests that as many as six hundred seventy-five thousand Americans died over a two-year period during the outbreak. There is little epidemiological or historical evidence that suggests the location of "patient zero."⁶ Most victims were young, healthy adults, suggesting that their own immune systems overreacted (also known as a cytokine reaction, often called a "cytokine storm"), filling the lungs with fluid in an attempt to combat the disease. Most deaths from other strains of influenza occur in those who are advanced in years or who are very young; Spanish Influenza departed significantly from that norm. The majority of deaths occurred from secondary bacterial infections such as pneumonia, but the virus itself caused hemorrhaging in the lungs resulting in a massive death toll. Infection rates were as high as 50% in numerous populations. No continent was left unscathed.

As is the case with many pandemics, this occurrence of influenza did not make a single sweep unleashing death across the planet; instead, it progressed in waves, with the second generation killing far more than the first.⁷ No other recorded pandemic infected and killed more people across the globe, except the bubonic plague (Black Death) of the 14th century.

Asian Influenza of 1957

The Asian Influenza was a pandemic outbreak of avian influenza that originated in China in early 1956; the pandemic lasted until 1958.

Unlike the Spanish Influenza Pandemic of 1918, the exact geographic origin of this pandemic was located. The disease originated from avian influenza mutation in wild ducks which combined with a pre-existing human strain. The virus was first identified in Guizhou. It quickly spread to Singapore by February 1957, reached Hong Kong by April 1957, and the U.S. by June 1957. Approximately 69,800 people in the U.S. died. Estimates of worldwide death tolls vary widely depending on source, ranging from one to four million. The Asian Influenza was identified to be the H2N2 strain of type A influenza, and an influenza vaccine was developed in 1957 to contain its outbreak. Modern medical advances are credited with making this pandemic relatively short lived, and is certainly credited with saving the lives of many people across the globe. The Asian Influenza strain later evolved by antigenic shift (a major RNA change) into H3N2 which caused a milder pandemic from 1968 to 1969. Both the H2N2 and H3N2 pandemic strains contained avian influenza virus RNA segments.⁸

Hong Kong Influenza of 1968

Related to the Asian Influenza Pandemic of 1957, the Hong Kong Influenza of 1968 was, in a sense, a mild pandemic as compared to the Spanish Influenza and the Asian Influenza. The Hong Kong Influenza pandemic killed an estimated one million people worldwide. In the U.S., the disease killed an estimated 33,800 people.

As the name implies, the disease was known to have originated geographically in Hong Kong. As is the case for several pandemics in the past, the disease originated as a cross between avian influenza, human influenza, and swine influenza; the host organism was determined to be swine, and the disease then passed on to humans.

The death rate was low for this pandemic; the fact that the Asian Influenza and the Hong Kong Influenza share the same neuraminidase protein distinction (N2), and that people

had been vaccinated against H2N2 influenza A as a result of the Asian Influenza may have played a significant factor in limiting the effects of the disease; however, cross-immunity is not generally well understood within strains and sub-types of influenza viruses. It is known that infection rates were fairly high in Hong Kong, but the mortality rate was low. As the disease spread across southeastern Asia, the death rate remained relatively low; people in that region still had a high immunity to the disease's effects. Within Hong Kong, infections peaked two weeks after the pandemic started (patient zero was identified to have been infected on July 13, 1968), and subsided six weeks later.⁹

Russian Influenza of 1977

The Russian Influenza of 1977–1978 was an epidemic caused by influenza strain A/USSR/90/1977 (H1N1). It infected mostly children and young adults under the age of 23; adults over the age of 23 were spared because of similar events which occurred between 1947 and 1957. These older adults had substantial immunity. Some have called it an influenza pandemic, but because it only affected the young, it is not considered a true pandemic. The virus was included in the 1978–1979 influenza vaccine.¹⁰ Mortality rates were very low.

Lessons Learned

History has shown that pandemics do not follow a set cycle. In the past, the CDC and WHO have made predictions that have not followed. Several predictions regarding avian influenza since 1997 have been localized, thereby earning the title of epidemic, but not pandemic; however, both organizations strongly suggested that the disease would be widespread and cause widespread infection and a significant number of worldwide mortalities. The most recent events of April and May 2009 were also touted to cause the same net results. However, the number of confirmed infections was significantly below what prediction models suggested.

People are certainly more well-

informed and well-connected in “the Information Age” than in previous generations. Using internet search engines yields a plethora of websites that offer advice; a number of them provide sound scientific principles that the ordinary person can take to prevent infection. The news media has also taken on an important role. Many newscasts have discussed the latest epidemic of Swine Flu; the media has suggested common-sense approaches proffered by both the Center for CDC and WHO are highly effective at limiting the spread not only of influenza, but other diseases as well. On the other hand, some communities went substantially overboard in dealing with the possibility of an epidemic; schools were closed, graduation ceremonies and proms were cancelled, and people visiting foreign countries were quarantined, even though none were sick.

Among the most important steps that the average person can take to prevent infection is vaccination. Vaccinations are prepared using the best guesses from each hemisphere's previous season's influenza strain. Many times, vaccinations are successful; however, influenza tends to experience antigenic drifts as time progresses. In that case, the virus's genetic information tends to drift slightly as the virus replicates itself in the host organism. At other times, a more dramatic antigenic shift occurs. In this case, the virus alters significantly, usually when the host has infections of different strains that combine in a host. A new strain of influenza is created as the RNA sequences combine to form a new pattern, which then must be typed. Antigenic drifts and antigenic shifts are the nemesis of vaccination programs. Small variations in genetic material can render entire vaccination programs useless.

An important step in preventing disease is keeping public places clean and sanitary. Using household bleach, alcohol, and sanitary wipes have been shown to be extremely effective in controlling the spread of disease. Some grocery stores have taken the precaution of using alcohol wipes to sanitize shopping cart han-

dles. Several news stories have aired and patrons expressed positive feedback that corporations were looking out for their personal welfare. Such stories, while rewarding on a personal level, are compelling evidence of what average citizens can do to prevent disease.

There is debate whether or not the CDC and WHO exercised too much caution in the April 2009 outbreak of Swine Flu, and whether such caution invoked panic and hysteria. With only two deaths reported among US citizens (note: those deaths were not conclusively linked to H1N1 Influenza A alone as of 10 May 2009) and widely varying numbers of deaths across the world for the first three weeks of known or suspected infections, WHO raised its pandemic influenza alert level to phase 5 on April 29. In a quote from Doctor Margaret Chan, World Health Organization Director General,

*"Ladies and gentlemen, Based on assessment of all available information, and following several expert consultations, I have decided to raise the current level of influenza pandemic alert from phase 4 to phase 5. Influenza pandemics must be taken seriously precisely because of their capacity to spread rapidly to every country in the world. On the positive side, the world is better prepared for an influenza pandemic than at any time in history. Preparedness measures undertaken because of the threat from H5N1 avian influenza were an investment, and we are now benefitting from this investment."*¹¹

The mission of these organizations is to assess the situation and respond in the best way possible. With the information available, the organizations executed their mission humanely and compassionately. Experts from around the world contributed to the decisions the Director General made. Dr.Chan's actions spurred many at the state and local level to make hard choices that ultimately have saved lives; it certainly limited the spread of H1N1 Influenza A. Predictive models indicated that H1N1 Influenza A would spread rap-

idly with potentially grave results.

As of early July 2009, the U.S. reported approximately 210 deaths related to, but not necessarily caused directly by, H1N1. The efforts and swift actions made by the CDC and WHO have minimized misery, suffering, and potential catastrophe.

The CDC and WHO initiated a campaign to educate the ordinary citizen regarding precautions people should take. Those efforts were effective, simple, and did not impact the struggling US economy adversely. Parts of the economy, notably medical supply firms, received orders for goods that exceeded quarterly demand for several quarters in the fiscal year. Suppliers of masks, for example, were overwhelmed by the urgent requests from many areas of the country. People took the advice of the WHO and CDC; their personal actions limited the spread of the disease, reducing the predictive models to "worst-case scenarios." Vaccine manufacturers have significantly increased volume of flu vaccine for the northern hemisphere's flu season, anticipating that H1N1 Influenza A could stage a massive return in the fall and winter of 2009 and 2010.

Conclusion

History has shown that pandemics are unpredictable and deadly, and that they can have dire consequences. From each pandemic of the 20th Century, medical science gleaned volumes of information. Advances in treatment, gene sequencing and identification, and vaccination programs each has contributed to saving lives. Common sanitation practices also contributed to preventing infection. The CDC and WHO took advantage of lessons learned from history, predictive models, and information that transited from across the globe to issue warnings and raise awareness. The actions of these organizations prevented a large-scale pandemic. While future historians may suggest and debate that the organizations overreacted, it is certain that their execution of events was systematic and that their recommendations saved lives. History has re-

corded instances where government and private organizations were too slow in reacting to developing situations to the detriment of populations; the CDC and WHO made the right recommendations. We have proven that we have learned from history. We have proven that fast action can prevent epidemics and pandemics. Though we have no cure for influenza, we can take significant protective measures at multiple levels to ensure that this, or any other disease we encounter, will not result in widespread illness, death, or other catastrophic impacts.



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ENDNOTES

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Nuclear Medical Science Officers: Army Health Physicists Proudly Serving and Defending Their Country Around the Globe

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Introduction

For over half a century, Nuclear Medical Science Officers (NMSO) have been a part of the Army Medical Service Corps, tracing their proud heritage and lineage directly back to the Manhattan Project and the subsequent nuclear weapon testing program¹



Nuclear Weapon Test "Upshot Knothole", Nevada Test Site 1953.

These commissioned officers are health physicists who wear the Army uniform and practice the craft of military health physics. The mission of the NMSO is:

*"to be a highly competent, dedicated, and professional Soldier scientist whose unique expertise is military health physics and whose solemn mission is to protect the war fighters and those they defend against harm from all sources of radiation, both military and civilian"*².

Currently, there are about 60 NMSOs on active duty with a comparable number serving in the Army Reserves and National Guard. The purpose of this article is to highlight some of the duties and responsibilities of Nuclear Medical Science Officers while they serve and defend the Nation. It discusses NMSO roles in medical health physics, deployment health physics, homeland defense, emergency response, radiation dosimetry, radiation research,

education, and training, support to Army radiation safety, and national and international scientific collaborations. The article closes with a discussion of NMSO career opportunities and a brief summary and conclusions.

Medical Health Physics

Over one third of the NMSO positions are located within Army hospitals and medical centers where they serve as medical health physicists. In these assignments, the NMSO serves as a radiation safety officer (RSO), ensuring the protection of patients, workers, and the general public from the use of radiation and radioactive materials in medical diagnosis, therapy, and research. Like their civilian counterparts, they manage medical radiation safety programs regulated by the Nuclear Regulatory Commission (except those facilities located outside of the United States, which are self-regulated by the Army). While in these medical RSO positions, NMSOs perform initial and annual radiation safety surveys of medical, dental, and veterinary x-ray systems. They also complete inventories and leak tests of radioactive sealed sources, ensure appropriate radioactive source security measures are implemented, maintain radiation dosimetry programs (to include bioassay), conduct fetal dose assessments, respond to radioactive spills and incidents, support inpatient radioiodine therapy and brachytherapy procedures, and perform shielding evaluations.³

It is through these hospital assignments that NMSOs develop and hone their technical skills so that they are ready to perform their "go to war" mission of assessing radiological risks and protecting others against radiation during military operations. Specifically, during these garrison assignments, junior officers are developed and mentored by more senior and experienced NMSOs, learning about radiation detection and measurement, radiation dosimetry, radiation shielding, and how to safely handle radiation sources and radiation producing devices.

Deployment Health Physics

Nuclear Medical Science Officers proudly wear the Army uniform because of their direct support to U.S. military deployments overseas, to include war. To date, over half of all NMSOs have deployed around the globe. These Soldiers have deployed to many countries, such as Afghanistan, Bahrain, Bosnia, Iraq, Korea, Kosovo, Kuwait, Montenegro, Qatar, Saudi Arabia, Serbia, Somalia, and Uzbekistan, along with a host of others. One of the critical roles that NMSOs fill during wartime operations is to serve



Nuclear Medical Science Officer serving as a medical Radiation Safety Officer and surveying a medical fluoroscopy system at Ireland Army Community Hospital, Fort Knox, Kentucky.



Figure 4. Nuclear Medical Science Officer (right) briefing Soldiers about radiation risks at the Tuwaitha Nuclear Research Center in Iraq.



Combat Theater Command Radiation RSO checking an area air sampler at a U.S. base camp in Iraq.

as combat theater RSOs; there is currently a Nuclear Medical Science Officer serving as theater RSO for each of the two wars the United States is fighting, one in Iraq and one in Afghanistan. These brave officers are responsible for all radiation safety issues, providing protection for over 150,000 deployed U.S. Soldiers, Sailors, Marines, Airmen, and Coast Guardsmen.

Among their many duties and responsibilities, the theater RSOs provide radiation safety training for the deployed units, manage physical security screening systems using radioactive materials or producing ionizing radiation, issue and exchange hundreds of personnel dosimeters, investigate incidents involving radiation exposure, recover and safeguard orphan radioactive sources, and perform routine measurements of ambient radiation levels.

Another example of important “down range” health physics support that NMSOs provide is conducting base camp assessment of areas where U.S. troops are bivouacked. These multimedia surveys include laboratory analysis of soil, water, and air samples. These environmental assessments ensure that personnel are not exposed to unsafe levels of radiation.

Nuclear Medical Science Officers also lead special teams that perform other field assessments to ensure troop safety. One of these special assessments was conducted when U.S. Forces secured the Tuwaitha Nuclear Research Center, the crown jewel of Saddam Hussein’s nuclear weapon development program during the early phases of Operation Iraqi Freedom. The massive 23,000 acre site outside of Baghdad was attacked by Coalition Forces and then subsequently looted and burned by local Iraqis.⁴ Because of this potentially hazardous situation, the White House directed that a special mission be launched to conduct a complex radiological risk assessment to determine if the more than 4,000 Soldiers and Marines guarding the massive site were in danger of overexposure to radiation, which thankfully they were not (See

Figure 4). Based upon in situ measurements and environmental sampling (air and soil), the highest upper bound dose equivalent for troops securing and patrolling the Tuwaitha Nuclear Research Center was estimated to be only 1.1 cSv, well below peacetime occupational radiation safety standards and therefore safe.⁵

In order to ensure that troops treated in a combat zone receive the same level of quality medical care that they would receive back home, NMSOs also support deployed military hospitals. These NMSOs deploy to conduct comprehensive surveys of medical, dental, and veterinary x-ray equipment, to include state of the art computed tomography systems.

As a result, U.S. troops wounded during their deployments are able to receive high quality diagnostic images with a minimal radiation dose, thereby ensuring both efficacy in their medical treatment and their medical safety.

Nuclear Medical Science Officers have served as the leader of the Army Contaminated Equipment Retrograde Team (ACERT) in Kuwait and surveyed hundreds of military vehicles, along with other items of equipment and material for radiological contamination prior to retrograding them back to the United States.

The Nuclear Disablement Team (NDT) is a special team deployed to disable enemy nuclear weapon programs. This elite team has received highly specialized training on nuclear weapon development technology (cascade impac-

tors, centrifuges, etc.) from scientists and engineers at the Department of Energy (DOE) and the measures required to safely disable equipment. While the NDT did not find any evidence of an active nuclear weapon development program in Iraq, it did secure, safeguard, and escort highly radioactive sources out of the war zone so that they could not be used as radiological dispersal devices, or “dirty bombs.”

In addition to their wartime mission, the NDT is capable of augmenting nuclear and radiological incident and accident response in the continental United States. The NDT is fully self-sufficient and can set up and operate a radiological decontamination “hot line”, processing scores of contaminated casualties, or members of the public who are not injured, but may have some external radiological contamination. Throughout the year, the NDT has a very robust training schedule designed to prove team capabilities and ensure team member readiness. Because of its unique assets and the ability to deploy quickly, the NDT has been available to support important political events such as the most recent Presidential Inauguration and the annual State of the Union Address. The NMSO assigned to the NDT serves as the RSO for the team and ensures the protection of the team members during their deployments at home and abroad.

Homeland Defense

Nuclear Medical Science Officers have been ensuring the defense of the American homeland since the founding of their specialty over half a century ago. During the attacks of September 11th, 2001, a NMSO deployed to the Pentagon after it was struck by one of the high-jacked planes in order to confirm the absence of radiological contamination from plane components, such as depleted uranium counterweights, or terrorist planted materials.⁶ Since early 2004, a NMSO has been assigned to the Pentagon Force Protection Agency’s (PFPA) Chemical, Biological, Radiological, Nuclear and Explosive (CBRNE) Directorate. This health physicist manages a vast integrated array of portal monitors and roving detectors in order to intercept anyone trying to sneak radioactive sources into the vast 3.7 million square foot building.

A senior NMSO is assigned to the Department of Homeland Security and currently working on nuclear interdiction technologies designed to identify and intercept covert radioactive sources



Nuclear Medical Science Officer surveying Abrams Tanks for radiological contamination in Kuwait.

CBRNE
Directorate Logo
Pentagon Force
Protection Agency.



being smuggled on the immense American interstate highway system.

Serving as the CBRNE Defense Staff Officer on the Army Staff, a Nuclear Medical Science Officer is responsible for developing and implementing Army policy in response to nuclear or radiological threats to the United States and her military forces. This officer is also responsible for procuring and stockpiling various medical counter measures, such as potassium iodide, chelating agents like zinc and calcium trisodium diethylenetriamepentaacetate (DTPA), and decorporating agents like Prussian Blue for use by U.S. Forces.

Nuclear Medical Science Officers have also been actively involved in evaluating prototype physical security cargo screening systems using radioactive materials or producing ionizing radiation in order to protect Army installations around the world.⁷

Emergency Response

Nuclear Medical Science Officers also stand ready to respond to nuclear or radiological accidents or incidents worldwide. During the infamous nuclear reactor accident at Chernobyl, a special scientific team led by a NMSO deployed to Moscow to assist the United States Ambassador in assuring that Americans living within the Soviet Union were safe.⁸ The Medical Radiobiology Advisory Team (MRAT) is another NMSO-led emergency response team that is located at the Armed Forces Radiobiology Research Institute (AFRRI) in Bethesda, Maryland and provides expert consultation on the medical management of radiological casualties and patient decontamination to the highest levels of the U.S. Government.⁹

The United States Army Radiological Advisory Medical Team (USARAMT) was originally created in 1964 in order to manage and treat casualties from U.S. nuclear weapon accidents¹⁰; since 9/11, this team has become a valuable medical resource for responding to incidents of nuclear or radiological terrorism.¹¹ The USARAMT has participated in many civilian exercises involving radiologically contaminated patients to include Operation Purple Haze, a Department of Homeland Security sponsored dirty bomb exercise at the Baltimore Raven's football stadium. This large exercise involved the deployment of all response assets from the City of Baltimore and the State of Maryland. The NMSO leader of the USARAMT served as the senior medical controller evaluating the overall medical response.¹² The USARAMT has also partnered with local civilian hospitals in the Washington, D.C. area by participating in mass casualty exercises involving radiologically contaminated patients.

These exercises are useful in coordinating joint responses and for the military and civilian responders to learn about each other's capabilities in a training environment, rather than during an actual radiological or nuclear emergency.

Located within the Defense Threat Reduction Agency



Nuclear Medical Science Officer leading the U.S. Army Radiological Advisory Medical Team during an exercise with a local Washington, D.C. civilian hospital.

(DTRA), the NMSO on the Consequence Management Advisory Team (CMAT) can conduct detailed modeling of nuclear or radiological incidents and predict fallout deposition. Other NMSOS at Army hospitals have participated in mass casualty exercises, to include a nationwide medical exercise testing the country's response to multiple radiological casualties.¹³

The NMSOs at the Armed Forces Radiobiology Research Institute were also key contributors to the "Medical Management of Radiological Casualties Handbook."¹⁴ This important reference is used as a resource the world over for the proper handling of patients from nuclear or radiological accidents or incidents. Another way that NMSOs have supported nuclear or radiological emergency response is through the drafting and publishing of the "CBRNE Battle Book", a convenient pocket sized reference guide for anyone responding to chemical, biological, radiological, nuclear, and explosive incidents.¹⁵ Also, NMSO expertise was sought for the groundbreaking development of coherent federal policy for responding to a nuclear detonation on American soil that included critical guidance to protect emergency responders from lethal levels of radiation in the aftermath of such a horrific event.¹⁶

Each of the fifty states has an Army National Guard

Civil Support Team - Weapons of Mass Destruction (CST-WMD) providing radiological monitoring and decontamination support within their respective states; the NMSO on these CST -WMDs serves as the RSO helping to ensure team safety. Recently, the 32nd CST -WMD participated in a high level exercise involving a simulated “dirty bomb” attack at the Baltimore Raven’s football stadium in downtown Baltimore Maryland. The exercise was very demanding and provided much needed realism to help prepare the team for its important mission in responding to radiation emergencies.

Radiation Dosimetry



Nuclear Medical Science Officer (right) with the 32nd Civil Support Team – Weapons of Mass Destruction (CST – WMD) participating in Operation Purple Haze, a dirty bomb exercise at the Baltimore Raven’s football stadium in Baltimore, Maryland.

Nuclear Medical Science Officers provide key support to the Army’s vast radiation dosimetry program that monitors approximately fourteen thousand Soldiers and Army civilians.¹⁷ Overseeing this massive program is the responsibility of the Radiological Hygiene Consultant to the Army Surgeon General, a NMSO Colonel and the senior health physicist in the Army. This critical medical oversight includes inspecting and evaluating the Army Dosimetry Center located on Redstone Arsenal, Alabama and investigating and validating all overexposures of Army dosimeters on behalf of the Army Surgeon General.¹⁸ Junior NMSOs operate the Deployable Dosimetry Laboratory (DDL), which is mounted on a lightweight military vehicle and capable of deploying to the field and processing hundreds of thermoluminescent dosimeters daily. The DDL is equipped to provide rapid and defensible dosimetry in support of deployed operations radiological emergencies.¹⁹ Nuclear Medical Science Officers have been part of the ongoing developmental effort to field a tactical radiation dosimetry system that is sensitive and accurate enough to provide National Voluntary Laboratory Accreditation Program (NVLAP) accredited dosimetric results.



Nuclear Medical Science Officer manning the Deployable Dosimetry Laboratory during a field training exercise at Aberdeen Proving Ground, Maryland.

In the area of internal radiation dosimetry, NMSOs manage the Army’s radiobioassay program, located at the Army’s Public Health Command at Aberdeen Proving Ground, Maryland; this program includes analyzing radiobiologic samples, calculating internal doses, and reporting the results to the individual, their healthcare provider, and the Army Dosimetry Center for archiving.²⁰ Part of the Army’s bioassay program includes screening returning troops from deployments for exposure to depleted uranium (DU) anti-armor munitions. To date, over 2,300 individuals have provided urine bioassays for analysis with only a handful showing measureable DU levels; most of these individuals had confirmed embedded fragments of DU from fratricide or “friendly fire” incidents²¹ with medical follow ups by the Veterans Administration. The large remainder of the Soldiers had no indication of depleted uranium intake, with urinary levels of natural uranium consistent with dietary levels reported by the Centers for Disease Control and Prevention.

Radiation Research, Education, and Training

Nuclear Medical Science Officers are also actively engaged in conducting radiation research and providing radiation education and training. NMSOs assigned to the AFRRRI conduct both radiobiology research and teach the Medical Effects of Ionizing Radiation (MEIR) course to all members of the Department of Defense; the MEIR course is recognized worldwide as a premier primer course on the biological effects of ionizing radiation and the health effects from radiation exposure. The NMSO assigned to the Uniformed Services University of the Health Sciences (USUHS) serves as the RSO for the university, which contains a medical school, nursing school, and the AFRRRI. This officer is also an adjunct professor on the USUHS faculty, providing radiation safety and health physics instruction to the myriad of courses offered at USUHS and assists students that are performing radiation related research.



Nuclear Medical Science Officer doing Electron Paramagnetic Resonance Radiation Biodosimetry research.

Most NMSOs conduct important health physics research during their Army funded fellowships for master and doctoral level degrees in civilian universities, thereby furthering the scientific knowledge about radiation and its health effects. Some of the research topics pursued by these officers have included: advances in radiation detection technology, computerized radiation safety training, improvements in accurate radiation measurement for diagnostic radiology, radiation biodosimetry, and decontamination technologies for fixed radiological contamination.²² Much of this important research is presented at professional society meetings, such as the Health Physics Society, or published in peer-reviewed scientific journals. It is important to note that all but two of the forty five references cited in this article are publications authored or co-authored by NMSOs while serving on active duty.

When questions were raised about the risks to Soldiers in armored vehicles struck with DU munitions fired by friendly forces, NMSOs took the lead in securing funding for and in the management of the complex five-year, six million dollar Depleted Uranium Capstone Aerosol Study and Human Health Risk Assessment.²³ This elegant research project measured the depleted uranium aerosols, their concentration and particle size distribution, resulting from the perforation of tank and armored personnel carrier crew compartments by depleted uranium kinetic energy penetrators.²⁴ As it turns out, individuals who were in these damaged vehicles at or near the time of impact and perforation, but were not wounded with depleted uranium fragments, received upper bound doses below U.S. peacetime radiation safety standards for emergency responders and these scientific results support the fact that depleted uranium is a safe anti-armor munition.²⁵

The Nuclear Medical Science Officer assigned to the United States Army Nuclear and Combating Weapons of Mass Destruction Agency (USANCA), Fort Belvoir, Virginia, evaluates and prioritizes the Army's biomedical research requirements for nuclear weapon effects and other weapons of mass destruction.²⁶ This NMSO also participates in research projects, such as the development of Soldier performance models for typical combat tasks, as a function of dose and time, subsequent to nuclear weapon detonations. These estimates give battlefield commanders an assessment of force effectiveness on the nuclear battlefield and are a part of Army doctrine. Another research project is the fielded of an unmanned aerial vehicle that can locate and identify radioactive materials or areas of radiological contamination while in flight.

While assigned to the Army Medical Department Center and School at Fort Sam Houston, Texas and the U.S. Army Chemical, Biological, Radiological, and Nuclear School, Fort Leonard Wood, Missouri, NMSOs provide training in the medical effects of radiation, to include the effects from nuclear weapon detonations. At the United States Military Academy at West Point, New York, a NMSO is on the faculty of the Department of Physics and teaches physics, to include health physics to the cadets. This instructor also serves as a positive role model and mentor for these future Army officers.

Nuclear Medical Science Officer Support to Army Radiation Safety

Nuclear Medical Science Officers provide vital ongoing support to the Army's large radiation safety program. In fact, the first Army Radiation Safety Officer (ARSO) was a NMSO who singlehandedly designed and implemented the corporate radiation safety program for the United States Army that continues to this day.²⁷ Currently, NMSOs support Army radiation safety by serving as members of the Army Radiation Safety Council and the Army Reactor Council, which oversees the Army's one of a kind Fast Burst Nuclear Reactor at White Sands Missile



Nuclear Medical Science Officer teaching Optics at the United States Military Academy, West Point, New York.

Range, New Mexico. Within Army Medical Command, a senior NMSO manages and oversees the worldwide system of hospitals and medical research facilities using radionuclides and radiation producing devices to ensure patient and worker safety.²⁸ To ensure regulatory compliance, junior NMSOs perform surveys and inspections of Army radiation safety programs around the globe. Additionally, Nuclear Medical Science Officers serve as part of Special Medical Augmentation Response Teams or SMART teams that respond to incidents involving potential radiological exposure of personnel and provide radiation risk communication.²⁹

In the area of Army policy, NMSOs helped to draft, staff, and implement the Army's Risk Management System. This decision model conveniently integrates all occupational and environmental risks, to include radiation, into a matrix that properly normalizes all operational risks during deployment and combat operations. This critical information then allows military commanders to make timely and informed risk management decisions during complex and dangerous military operations.³⁰

When Army veterans with health problems inquire about potential radiation exposure during their service, NMSOs at the Army's Veterans Radiation Exposure Investigation Program (VREIP) conduct a detailed investigation in order to assess radiation exposure and determine dose. This research include reviewing veteran service records to confirm duty assignments, locations, and dates, querying archived radiation dosimetry records, and estimating upper bound radiation doses for veterans who were not issued or did not wear personnel dosimeters. The results of the VREIP investigations are sent to the Department of Veterans Affairs so that the diseases and illnesses.

National and International Scientific Collaborations

Because of their knowledge, NMSOs have lent their scientific expertise and served the national and international scientific community. A NMSO served as a representative to the multi-agency working group writing Federal Guidance Report No.14, Radiation Protection Guidance for Diagnostic and Interventional X-ray Procedures. As head of Delegation to the North Atlantic Treaty Organization (NATO), NMSOs forged standardized agreements to handle and process nuclear combat casualties.³¹ Nuclear Medical Science Officers have also consulted on the health and environmental effects of depleted uranium by serving as consultants to the World Health Organization (WHO) and the International Atomic Energy Agency.³² An NMSO also served as a member of the international scientific team sent by the United Nations to the Balkans to assess the health and environmental risks from the use of depleted uranium by NATO forces and which concluded that these risks were not significant.³³

When the Nicaraguan Government had concerns about the safety of its radioactive waste disposal facility because of an outbreak of illnesses in individuals working on a construction site adjacent to the building, a NMSO led the scientific mission to perform radiation measurements and

assess the radiation risk. The team found the facility to be safe, briefing this to the U.S. Ambassador to Nicaragua and the head of the Nicaraguan Atomic Energy Commission. They also provided useful recommendations to further enhance the physical security of the radioactive waste disposal site and better safeguard the highly radioactive radium brachytherapy sources stored there.³⁴



Nuclear Medical Science Officer (on the left) serving as part of a United Nation's mission to Kosovo.

Nuclear Medical Science Officer Career Opportunities

Health physicists who choose to become NMSOs receive commissions as Army Officers in the Medical Service Corps and can serve on Active Duty, in the Army Reserves, or in Army National Guard. The rank at which one enters the Army is dependent upon the level of education attained and the amount of health physics experience of the individual. For example, a health physicist with a bachelor's degree in health physics or a related field (like nuclear physics or nuclear engineering) would receive a commission as a second lieutenant. Individuals having an appropriate master's degree would be commissioned as a first lieutenant, while those with an appropriate doctoral degree would come into the Army as a captain. Initial assignments for NMSOs are typically at Army medical centers as Deputy Radiation Safety Officers or at the Army Public Health Command as junior health physicists; it is during these initial assignments that new NMSOs learn about Army health physics and Army officership while receiving guidance and mentoring from senior Nuclear Medical Science Officers.

Typically after two assignments, NMSOs are eligible to compete for highly coveted, fully funded fellowships to

pursue graduate degrees (masters or doctorates) in health physics. During graduate school, these officers receive their full pay and allowances while incurring no student loan debt. After graduation, these health physicists are then assigned to duty positions where they can effectively utilize what they have learned in school.

As they continue their careers, NMSOs take on assignments with greater and greater responsibilities that further develop and groom them to become senior Army health physicists and Army leaders. Once NMSOs are promoted to the rank of major, they become field grade officers and can fill more advanced technical positions and begin leading junior Nuclear Medical Science Officers. Lieutenant Colonel and Colonel NMSOs serve in senior Army and Defense Department staff positions making and overseeing radiation policy. Highly competitive NMSOs have also been selected to serve in command and chief of staff positions, having the distinct honor of leading both Army units and Soldiers.

Throughout their careers, NMSOs receive competitive pay and benefits as compared to their civilian colleagues, to include pay increases for longevity, promotions, and annual cost of living increases (See Figure 1). This lucrative pay includes a non-taxable allowance for housing that is dependent upon the cost of living for the area where the officer is assigned and an allowance for subsistence. Also, many states across the country do not tax military pay while an officer is serving on active duty.

Competitive pay and allowances for NMSOs continue as they stay in the service, making the Army a highly worthwhile career option (See Figure 2).

After serving 20 years or more, NMSOs may retire, receiving a military pension for the rest of their lives. After a Nuclear Medical Science Officer completes an Army career, he or she usually has experienced the entire breadth and depth of the health physics profession and looks back upon his or her service with great pride and a real sense of accomplishment. Most of these retired officers then find successful employment in the civilian sector as they start second health physics careers, while some choose to completely retire and travel or pursue their treasured hobbies and interests fulltime.

Summary and Conclusions

The purpose of this article is to provide an overview of the roles and responsibilities of NMSOs, along with a glimpse of unique experiences and opportunities for these uniformed military health physicists. Established in the aftermath of the development and use of the world's first atomic bomb, the Nuclear Medical Science Officer has served with distinction as skilled leaders in the Army Medical Department. These highly trained and competent Army officers serve in an array of capacities around globe, ensuring that those who fight our Nation's wars are protected against the potentially harmful effects of radiation, regardless of the source.

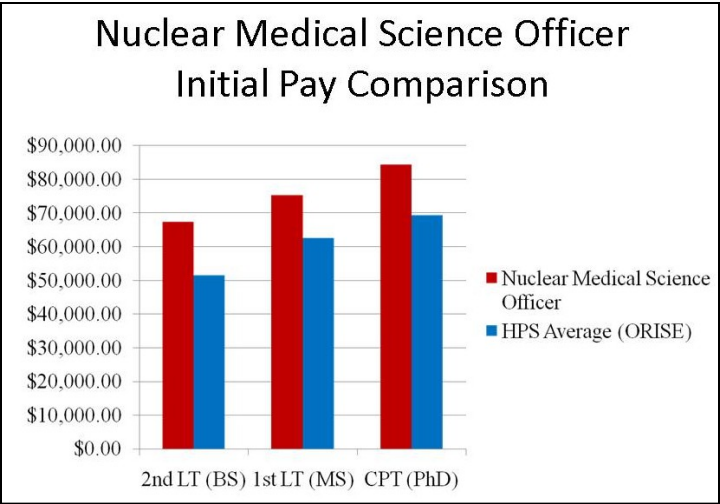


Figure 1. Starting annual salary for Nuclear Medical Science Officers as compared to median starting annual salaries for health physicists based upon academic degrees: Source – Salary Information for Health Physicists and Nuclear Engineers, Oak Ridge Institute for Science and Education (ORISE), 2009 (Nuclear Medical Science Officer pay includes base pay and allowances for housing and subsistence and \$12,000 for the healthcare benefit.)

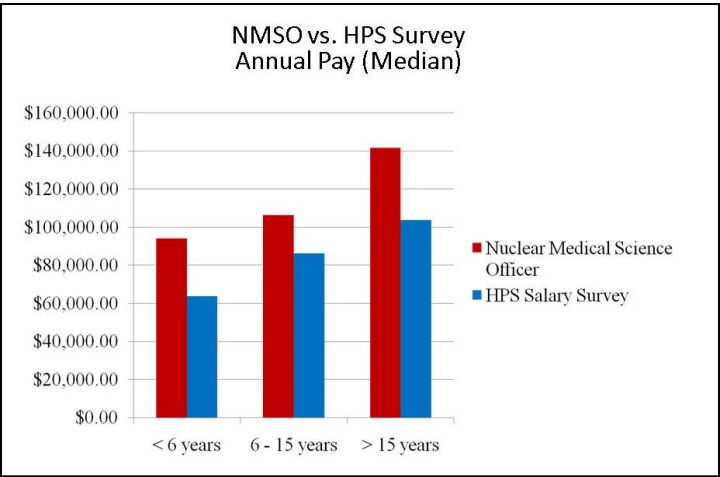


Figure 2. Long Term Comparison of Median Nuclear Medical Science Officer Annual Pay as Compared to Median Health Physics Salary Survey Data: Source – HPS Salary Survey 2007 (Nuclear Medical Science Officer pay includes base pay and allowances for housing and subsistence and \$12,000 for the healthcare benefit.)

Whether they serve in an Army hospital, deploy with units to combat zones, stand ready to ensure homeland defense, respond to radiation emergencies, conduct radiation research, education, and training, support Army radiation safety, or collaborate with national and international scientists, the Army's NMSOs continue a proud tradition of serving and defending the United States of America in places both near and far while practicing their craft of military health physics. Nuclear Medical Science Officers are truly "Nuclear Medics", sharing a proud legacy and forging a bright future by continuing to protect the world's best warriors against the world's most deadliest weapons.

Individuals interested in pursuing an exciting and rewarding health physics career as an Army Nuclear Medical Science Officer can contact Colonel Mark A. Melanson, Radiological Hygiene Consultant, Career Field Leader for the Army's Nuclear Medical Science Officers, at (202)-356-0058, Monday through Friday, 9:00 a.m. to 4:00 p.m., EST, or send him an email via his email address at mark.melanson@us.army.mil. To contact a local Army recruiter or to obtain additional information about joining the United States Army, go to www.goarmy.com.



Colonel Melanson is the Nuclear Medical Science Consultant to the Army Surgeon General and the senior health physicist in the Army. He has a bachelors degree in physics from Dickinson College and a master's degree and a doctorate in radiation health sciences from the Johns Hopkins University, and certified health physicist (CHP). His assignments include Radiation Safety Officer (RSO), Landstuhl Army Regional Medical Center; health physicist, U.S. Army Environmental Hygiene Agency; Project Engineer, Johnston Atoll Plutonium Remediation Project; Radiation Hygiene Consultant, Headquarters, U.S. Army Materiel Command; Program Manager, Health Physics Program, U.S. Army Center for Health Promotion and Preventive Medicine; Director, Radiation Safety, Walter Reed Army Medical Center; and Leader, U.S. Army Radiological Advisory Medical Team. OCONUS assignments include Germany, Johnston Atoll, Kosovo, Bosnia, and Iraq.

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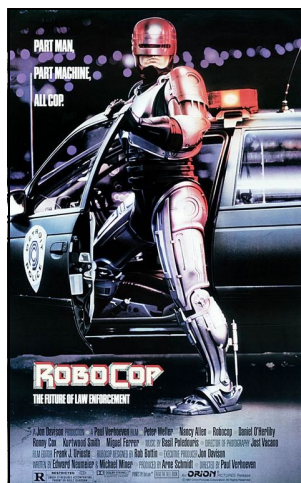
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What the Future Warfighter Might Look Like?

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Over the past few years, the author has been following the development of new technology as a series of advancements that could have military applications [Further Reading 1 & 2]. It is now possible to be more specific. These projections are the opinion of the author and are not necessarily under current development.

Nanowarrior – the 21st Century Robocop! The ability of scientists to see down to the nanometer level and control the development of materiel with essentially zero defects or precisely controlled defects means it is possible for engineers to fabricate incredible new products that can outperform even the presently conceived 2010 version and 2020 (Darth Vader) version of Future Force Warrior (Figure 1). Some of these applications include advanced Command, Control, Communication, Computers and Information (C4I), medical breakthroughs, mission completion using minimum power, and combat uniform systems of smart material, reduced carrying weight, and increased weapon lethality.



MGM Studios Poster ©

1(a) Robocop ®

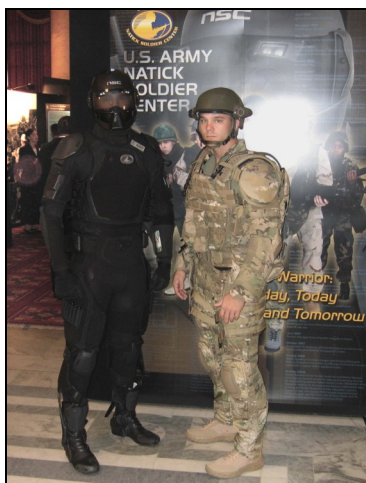


Photo: DoD

1(b) Future Force Warrior

Figure 1. Nano Warrior - the 21st Century Robocop.

In addition to nanotechnology applications, it is reasonable to assume dramatic advances in unmanned aerial vehicle (UAV) and unmanned ground vehicle (UGV) platforms, systems, guidance and control as well as new insulating materials and lightweight armors. One such materiel



Figure 2. Aerogel, One of the World's Lightest Solids.

[Further Reading 3]

is Aerogel, aka “frozen smoke” (Figure 2). Aerogel can withstand a direct blast of 1kg of dynamite and protect against heat from a blowtorch at more than 1,300 °C. [Further Reading 3]

Listed at Table 1 are some specific military applications for these new technologies that might be fielded within the next ten to twenty years.

So just what does all this mean to the warfighter? Consider the following comparison of a small group (perhaps as many as 10 personnel) of today's and future warfighters on a three-day mission in (1) a jungle-like environment, and (2) a desert-like environment. Only some of the above applications will be mentioned.

In both cases, today's warfighter would likely wear combat uniforms, body armor, helmet, boots and would carry a ruck sack (about sixty pounds), possibly a radio (about seven pounds), and a weapon (about ten pounds). As you can see, weight reduction is one of the most critical concerns for today's warfighter; stealth is another.

The future warfighter on the same mission would have improved combat uniforms, helmet, and boots that would incorporate a wide range of new technology to significantly reduce weight (by as much as 50%) and vastly improve warfighter daytime and nighttime capabilities. For short range, time-sensitive, secure communication, the warfighter might use a carbon nanotube transceiver cut to desired frequencies. These ultralight nanotransceivers and their associated nanocomputers would draw such low power that power generators could be derived from thermoelectric circuits or solar cells woven in the combat uniform or helmet. Insulated combat uniforms, helmets and

Table 1. Possible New Technology Applications 10-20 Years.

Military Application	Specific Application
C4I	Nanotransceivers, nanocomputers, advanced sensors and thermal imagers
Medical	Wound healing, blood clot protection (microbots), improved medications, real-time warfighter monitoring, and ultrasensitive chem /bio detectors
Power Generation and Storage	Body heat/useable power conversion, solar cell storage, ultra light insulation
Uniforms	Lighter body armor, exoskeleton support, cloaking capability, waterproof materials, and improved CBRN protective suits, filtration media and decontaminants
Weaponry	Lighter weapons, improved ammunition, UAV/UGV support
Improved Platforms	Lighter vehicles, more silent engines, stronger armor, more slippery nautical surfaces

boots could use next-generation aerogels, presently the world's lightest material. Aerogels could also be made into body armor and even to filter polluted water. Combat uniforms would have medical capabilities as well. For example, bleeding wounds would be staunched using combat uniform or aerogel material that is antibacterial.

fighters within twenty years? No, but the technology is maturing rapidly enough that Special Forces could benefit from some or all of these breakthroughs well within twenty years.



Warfighters in a Jungle-like Environment

These same future warfighters would benefit not only from the developments mentioned above, but they would also use flexible, biocompatible rubber films for use in implantable or wearable energy harvesting systems. Combat uniforms could be made to wick moisture away from the body and equipment could be made waterproof. Waterproofing boat surfaces would reduce drag to more silently extricate personnel from danger and return them during night or day to base camp using low noise, low heat-producing electric motors or hydrogen fuel cells. Prior to their deployment, future warfighters would be given nanomedicines to protect them from jungle toxins and diseases and to provide their commanders with real-time monitoring of battle stresses.

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Warfighters in a Desert-like Environment

Desert combat uniforms would cool the warfighters body core temperature and generate electrical power from body heat or sunlight. Solar powered electric motors (daylight travel) or hydrogen fuel cell powered vehicles (nighttime travel) would move warfighters noiselessly through the desert while generating low thermal profiles. These new applications, and those mentioned above, would vastly reduce the weight carried by warfighters yet increase their ability to successfully complete their mission.

Does anyone know this will happen for all future war-

The Need to Redefine Electromagnetic (EM) Protection: “A Think Piece”

Robert A. Pfeffer

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Introduction

The traditional approach used to protect Army circuits supporting such critical missions as command, control, communications, computers, and intelligence (C4I) and weapons delivery is no longer sufficient to protect them from the evolving Twenty-First Century electromagnetic (EM) threat. Several recent DOD decisions, coupled with a dramatic increase in electronically sophisticated individuals, terrorist groups, and organized states intent on compromising Army electronic superiority, have already led to an increased sensitivity of Army circuits. This increased sensitivity provides a convincing argument that future Army circuits supporting critical missions must be protected against not only unacceptable upset, catastrophic damage, or both (referred to in this article as either traditional EM protection or E3 protection) but also against cyber and information attack (referred to in this article as non-traditional EM protection).

This article first looks at the present EM threat and the approach Army takes to protect electronics against it. Two recent DOD decisions that have increased Army circuit sensitivity and accelerated the need to redefine the term EM protection are then highlighted, followed by a discussion on the growing cyber threat against Army C4I. The status of Army system protection against the total EM threat is then identified. Finally, the article concludes with a discussion on how some of the emerging technologies could enhance protection against this new EM threat spectrum while reducing overall life cycle protection costs.



The Present EM Threat and System Protection

EM Threat from E3-induced Stresses.

Over the years, the Army successfully protected critical circuits from a diverse EM threat. This threat originated from EM environments (EMEs) that stressed electronic circuits. The EMEs were generated a number of ways, so they could be deliberate or non-deliberate, manmade or natural. Such diverse origins meant EMEs could be narrow band or wide band, and they could be in-band or out-of-band relative to the electronics of concern. And once these EMEs were coupled onto a system, the resultant electromagnetic environmental effects (E3s) were sensed by input/output circuits as unwanted current and voltage stresses. The stress magnitudes then determined whether they were a threat to the circuit. If the stresses were high enough, they were known as traditional EM threats.

There is an in-band component of E3 that is addressed by Army Electronic Warfare (EW). This E3 component is discussed later in the article. Table 1 provides a list of some of the

more common present-day EMEs that have been an EM threat to Army equipment.

The fact that circuits “see” only voltages and currents and do not care how they originate outside the circuit have prompted many Army system designers and test and evaluation personnel to use a simple, yet effective approach to E3 protection [Further Reading 1]. It is called Unified E3 Protection (UE3P), and it uses the barrier concept to isolate sensitive circuits from those EMEs and E3s. This approach has been used to substantially reduce the cost of system E3 protection by making protection a part of the original system design.

Present EM Protection. Critical circuits are generally associated with equipment that support critical missions. Thus, they are often found on weapons delivery systems and C4I systems. In the days when critical electronics were built to military specifications, circuits were generally analog and usually very rugged. Hence, most only had to be protected against catastrophic failure. (An exception to this rule was electronics that required protection even during exposure; e.g., Identification Friend or Foe (IFF) systems.) Catastrophic failure was therefore the primary concern for analog circuit designers of the 1950s and most of the 1960s. One would assume protection against catastrophic failure would be relatively inexpensive, especially if design engineers considered E3 protection collectively early in system design. Unfortunately, protection and test verification was often done separately for each EME and in some cases was done after equipment design

Table 1. Typical EMEs. [Further Reading 1]

Externally Generated Electromagnetic Environments			
Environment	Type	Waveform	Propagation
Nearby Lightning	Natural	Pulse	Radiated and Conducted
Direct Lightning	Natural	Pulse	Conducted
HEMP)	Hostile	Pulse	Radiated and Conducted
SREMP	Hostile	Pulse	Radiated and Conducted
Electromagnetic Emissions	Electronic Operation	Pulse, CW and Modulated CW	Radiated and Conducted
HIRF	Electronic Operation	CW and Modulated CW	Radiated and Conducted
ECM (backdoor)	Hostile	Modulated CW	Radiated and Conducted
RF Weapons (HPM, UWB)	Hostile	Pulse, CW, Burst of CW, modulated CW	Radiated and Conducted
P-Static	Natural	Pulse	Conducted

Internally Generated Electromagnetic Environments			
Environment	Type	Waveform	Propagation
Electromagnetic Emmissions	Electronic Operation	Pulse, CW, and Modulated CW	Radiated and Conducted
ESD	Natural	Pulse	Radiated and Conducted

Table 1. Typical EMEs Legend.

HEMP – High-altitude Electromagnetic Pulse
 SREMP – Source Region EMP
 CW – Continuous Wave
 HIRF – High Intensity Radio Frequency
 ECM – Electronic Countermeasure
 HPM – High Power Microwave
 UWB – Ultra-wideband
 ESD – Electrostatic Discharge

(commonly referred to as retrofit) to enhance the signal-to-noise ratio (SNR) for performance.

With the advent of digital electronics in the late 1960s and early 1970s, however, electronic circuits became considerably smaller, more sophisticated, and often more susceptible to a given noise level. The occurrence of unacceptable upset increased, and with it, the need for electronics designers to provide additional protection against upset. And even though today's electronics are digital and more sensitive, and modern day EM threats can cause both catastrophic failure and unacceptable upset, equipment protection is no longer a significant cost driver. An example of protection costs for legacy and future systems is provided later.

It should be noted that even though protection against both unacceptable upset and catastrophic failure is affordable, it is still widely regarded as a survivability (not an operational) requirement. Program managers (PMs) consider survivability to be in their "trade space", since it is not a key performance parameter (KPP) per DODI 5000.02 guidance [Further Reading 2]. Thus, EME susceptibilities that program managers might accept up-front in their acquisition programs could later result in noise degrading the SNR. This degradation is not always evident in the ambient silence of Power-Point presentations, simulations, and/or laboratory environments those same PMs use to support their program survivability trade-off plan.

The relatively high-level, in-band EM threat (mentioned earlier) contin-

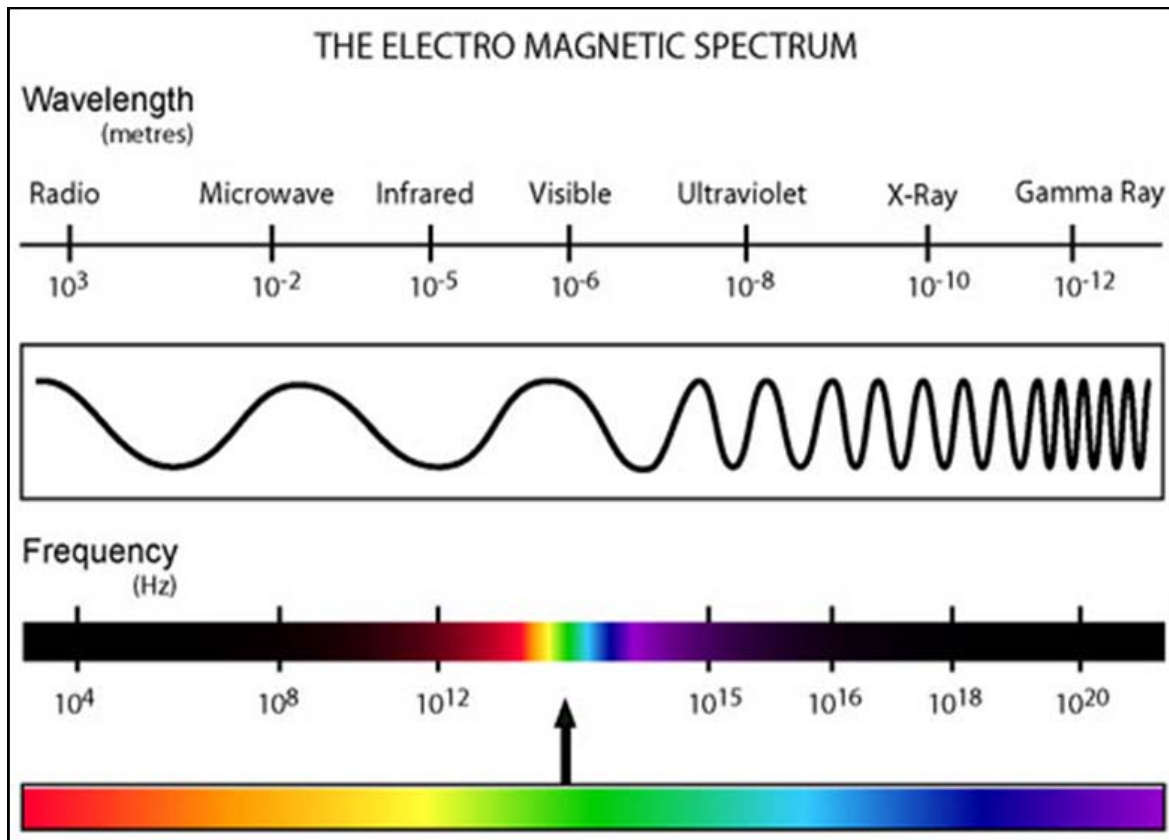


Figure 1. The EM Spectrum of General Interest to DOD.

ues to be the responsibility of the Army EW community, a community typically composed of Army operators, frequency managers, and intelligence engineers. Thus, their primary responsibilities are offensive and defensive C4I jamming and circuit damage. Since in-band C4I details are often close-hold, the EW community does not interface directly with the E3 community on equipment and network survivability/vulnerability. Hence, the E3 and EW communities continue to develop their own sometimes-unique approach to circuit protection. Unfortunately, this independent approach is not the most cost-effective way to protect against new, evolving in-band, non-traditional EM threat that could compromise circuit security without being identified.

Recent DOD Decisions Affecting System Protection

Two recent DOD decisions that have already affected Army digital circuit sensitivity and their EM protection are (1) the move toward a net-centric wireless long-haul C4I system, and (2) the support of auctioning to the commercial community a significant number of DOD-controlled frequencies, sub bands, and bands.

Perhaps the most dramatic change in military C4I structure has been the DOD decision to move to a net-centric wireless long-haul C4I system. In 2002, the Assistant Secretary of Defense for Networks Information Integration (ASD (NII)) released DOD Directive 8100.01 *Global Information Grid (GIG) Overarching Policy* [Further Reading 3]. It describes the net-centric structure of the

new DOD long-haul backbone. For Army, it means that C4I survivability must now include Army portals to the GIG. And because the GIG is essentially a computer-based system, GIG security becomes an Army survivability issue. Future Army C4I is therefore dependent not only on GIG survivability but on the ability of the GIG to be free from individuals and/or organizations that use their computer-based knowledge to gain unauthorized access to the net-centric wireless network ("hackers"). Recent articles have shown both hacker types are an increasing threat to DOD-owned computer-based systems [Further Reading 4, 5, and 6].

At about the same time, DOD began reducing the number of frequency bands they controlled for military purposes by making many of those bands and sub bands available to the commercial community. These frequencies and wavelengths are centered near the visible spectral range, as shown in Figure 1.

Starting in early 2000 and still continuing, the DOD saw much of the traditional military spectrum auctioned off to commercial companies for use in the private sector (e.g., cell phones, first responder communication nets, and radio frequency data links). The auctions have proven so successful there is now less dedicated military spectra with greater signal concentration in specific parts of that spectrum. Figure 2 illustrates the present status of military and commercial use of this crowded spectral range.

Figure 2 implies that the remaining spectrum controlled

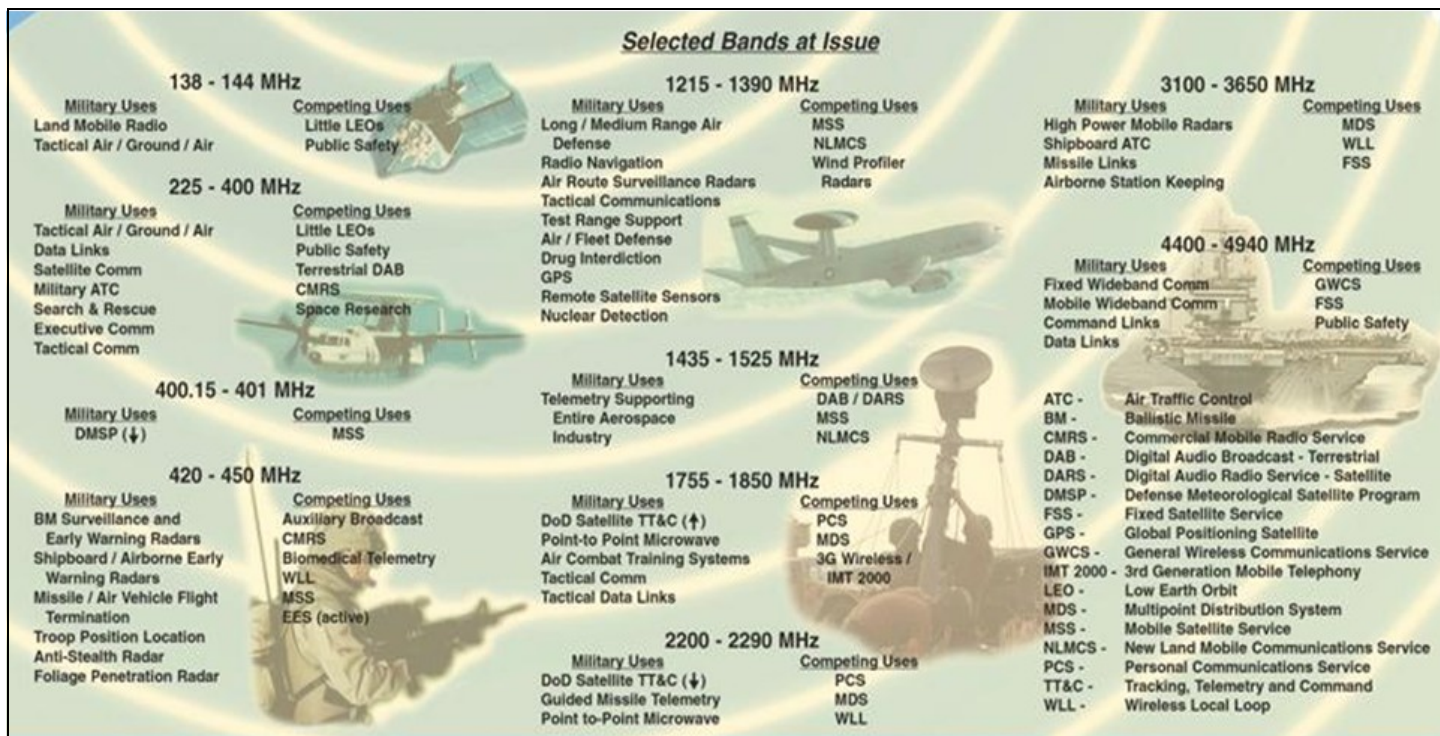


Figure 2. Specific EM Bands of Both Military and Commercial Interest.

by the military has been reduced to a modest percentage of the total spectrum the DOD once controlled. As the military spectrum decreases, our reliance on new technology to protect the spectrum increases. In fact, more and more sophisticated electronics are being designed to replace or supplement human situational awareness and decision making. The age of unmanned aerial vehicles (UAVs) and extremely small and intelligent battlefield sensors has already arrived. Soon, fighter aircraft and mobile ground vehicles could be unmanned.

The decision on the part of the U.S. military to use low power, small feature size components (including nanotechnology electronics) has not gone unnoticed. The international community has increased its interest in advanced electronics, electronic warfare, and electronic defeat. In fact, it is not unreasonable to assume future battlefield sensors will be developed that can passively find military electronic signals, determine their operating characteristics, and then actively defeat them.

Status of Army System Protection

Great News – EM Protection Against Most Out-of-Band Threats. As they relate to critical Army systems, wide band and narrow band EMEs can couple their energy onto system cables and other forms of non-deliberate antennas. These out-of-band signals can drive input/output circuits beyond their normal operating levels and lead to catastrophic failure. By simply limiting these and other induced signals to (or below) normal operating levels, design engineers have protected equipment supporting critical Army missions for very little cost (as low as < 1% of the equipment per unit cost). When the coupled wide band or narrow band signal has a substantial amount of

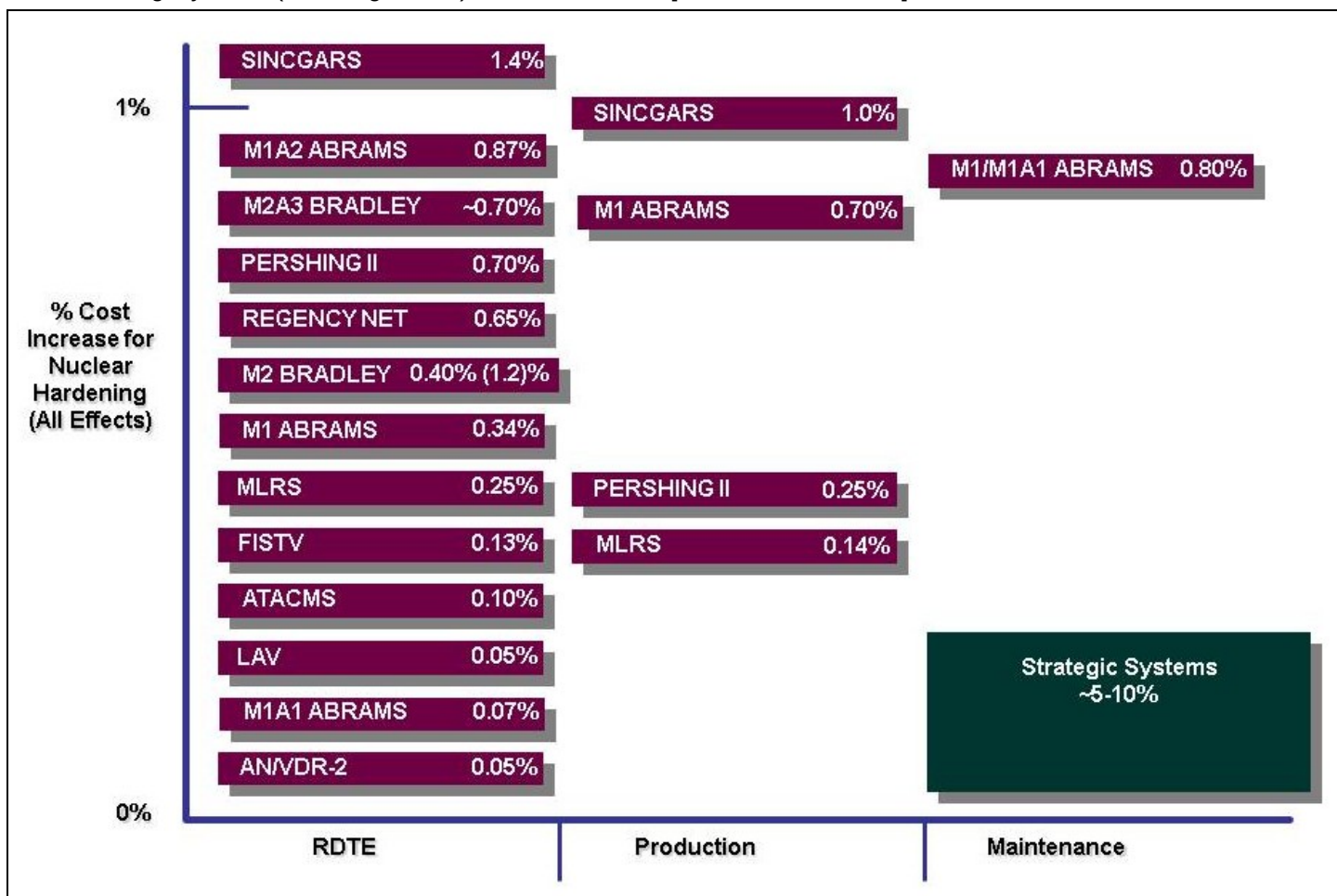
energy in-band (e.g., HEMP onto FM or lightning onto AM transceiver antennas), the unwanted signal will degrade SNR performance and cause unacceptable upset to internal clocks or even catastrophic failure to input/output circuits. In both cases, the same approach to protection is used. That UE3P approach uses the barrier concept: potentially sensitive electronics are isolated from external EMEs by the use of shields and shield penetration controls, whose attenuation levels are set from circuit design margins selected by the PMS. And it has been used for addressing all forms of E3 protection, especially for out-of-band and some forms of in-band protection. Table 2 (following page) provides a bar chart of system protection costs. These costs reflect legacy system costs for protection against all nuclear weapons effects (NWE), including HEMP. The table was originally prepared for the Defense Threat Reduction Agency by Army Test and Evaluation Command at White Sands Missile Range (ATEC DATS WSMR).

Table 3 (page 38) identifies estimated protection costs for the Future Combat System (FCS) for several UE3P application cases: HEMP alone, HEMP integrated with all NWE, and HEMP integrated with all other EME. ATEC DATS WSMR data were used to compiled in the Table.

The data in both Table 2 and Table 3 support the conclusion that the cost of designing in protection against the traditional EM threat is not only low (and therefore affordable) but it is also continuing to decline.

Good News - EM Protection Against Present In-Band Threats. Perhaps the most challenging protection scheme for circuit designers is protecting critical electronics from in-band threats. While it is possible to limit in-band signals

Table 2. Legacy NWE (Including HEMP) Protection Costs. [ATEC DATS WSMR]



to normal operating levels, it is extremely difficult to eliminate them entirely or to stop them from interfering with normal transmission and reception. In the past, antennas were protected from unwanted signals with high capacitance metal oxide varistors (a type of surge suppressor) placed at the antenna base. This in-band protection worked well for analog circuits, where protection was only against catastrophic circuit failure due to a high-amplitude signal pulse. Message upset was acceptable as long as the message could be repeated, but it allowed systems to be jammed by a burst of in-band signals. The challenge of the EW community was, therefore, to find the frequencies of the opponent's electronics and then re-transmit them at high enough signal strength to jam or destroy circuits while at the same time protecting their own electronics from hostile EW attack. Jamming or destroying circuits are just two of many in-band problems confronting future C4I systems, but they might not be the most insidious.

So, the good news is the Army knows how to protect their electronics against most in-band EME pulses as well as most out-of-band EMEs.

Not-so-good News – The Evolution of Asymmetric Threats. The bad news is recent battlefield successes of modern U.S. military electronics has exposed a possible Achilles heel. Rogue nations and extremist groups now

realize it is both difficult and costly to confront the US using traditional military tactics and equipment. To gain the advantage, they might attempt to overcome the technological advantage the U.S. now has in weapons, sensors, C4I, and weapons guidance systems. However, this commitment to develop and maintain advanced technology involves a substantial, long-term investment in state-of-the-art weapons and semiconductor development. Instead, rogue nations and terrorists prefer to fight on their own terms, such as prolonging a low-level conflict, inflicting casualties on U.S. forces in guerilla-like warfare and using commercial-off-the-shelf (COTS) equipment to take advantage of readily available advanced technology. In these cases, a reliance on asymmetric threats is a real option, and some of them could be electromagnetic in nature.

Consider several trends that confront the U.S. military as it strives to maintain an edge in EM protection.

Reality: High-tech Expertise Has Moved Off-shore. Most of the electronics technology now comes from Asia, an area with massive populations and a growing academic and industrial presence in semiconductor technology. Already, China and India are developing their own semiconductor technology expertise. They are graduating many more electrical engineers and computer scientists than the

Table 3. 2007 FCS Protection Costs Estimates. [ATEC DATS WSMR]

	E3 (Includes HEMP)	HEMP (Unique)	NWE (Includes HEMP)
<u>Labor LSI</u>	\$27M	\$3.33M	\$1.2M
<u>Labor OTP</u>	\$30M	\$3.0M	\$33M
<u>Material</u>	\$18M	<\$0.010M	\$76M
<u>T&E</u>	\$2.6M	\$0.27M	\$2.7M
<u>Total</u>	\$77.6M	\$6.61M	\$112.9M
<u>% RDT&E</u>	0.267	0.023	0.389

US; some estimate as many as 5-times more [Further Reading 7]. In addition, India has the world's greatest concentration of software engineers and programmers with China a close second. These trained engineers and scientists, plus countless untrained "hackers", could very well be directing their activities toward compromising electronics and electronic systems. The U.S. press has recently accused the Chinese of successfully hacking into some Pentagon computer systems [Further Reading 5 and 6]. Other friendly nations (Japan, Taiwan, and Singapore) are very sophisticated electronically and they, too, could be developing their own techniques for intercepting messages and inserting misinformation. It therefore wouldn't take very long for any of them to look at new ways to compromise sophisticated electronics. All these newly trained and untrained people are making the next generation C4I potentially more vulnerable to the evolving new EM threat.

Reality: The In-band Threat Continues to Evolve. Consider for a moment a way of compromising sophisticated electronics. Instead of trying to cause unacceptable upset or catastrophic failure, both of which would be recognized compromises, a potential asymmetric threat technique would be to "hack" into the system and at the appropriate time insert electronic signals at a circuit's normal operating level to "fool" the circuit security software into thinking it is receiving a legitimate signal. Such a threat is possible today, and it is constantly evolving into a more serious problem. In the future, more widespread attacks during peacetime and military conflicts could lead to catastrophe: civilian databases (e.g., banks, stock market, federal government) could be manipulated, and military C4I systems, Global Positioning System, autopilots, even sensor circuits could be compromised. Traditional EM protection will not stop this EM threat. System security can only be protected using software techniques.

The above example is one of a hostile force deliberately attempting to compromise a mission critical system. A second in-band example is one that starts out as a non-hostile EM problem. It illustrates how the military can inadvertently create a threat on their own equipment by fielding new technology before conducting a thorough test program and deployment strategy. In 2002, the DOD Directed Energy Test and Evaluation Capabilities Study

completed a comprehensive analysis of testing facilities that would be required to assess both blue and red force systems. A capability was then developed based on 2002 force-on-force specifications for systems and threats. In the intervening years, the global war on terror resulted in new and different systems that warfighters quickly developed and fielded. Some of the systems sent to theater used commercial frequencies that DOD did not plan (nor were authorized) to use in 2002. This deployment was done in order to rapidly field new COTS-developed emitters that generate much higher frequencies and field strengths than were originally designed for use on 2002 light tactical vehicles. The result was a blue-on-blue force EM threat problem not originally anticipated. These results, if obtained by hostile forces, could be used to jam or damage fielded Army systems deployed in the field by simply purchasing equivalent COTS generators sold by commercial vendors and using them in the field.

These examples and other new forms of asymmetric EM threats could be used not only by rogue nations but also by radical groups. Future asymmetric sources could be smaller, more directed, use less power and be far less expensive than present high power EM sources. All an adversary would need is specific transmit and receive knowledge for the targeted electronics devices. And with the DOD selloff of many frequency bands and sub bands, the remaining frequency bands and sub bands would be more readily identified on the battlefield and more easily attacked.

This new asymmetric approach to compromise weapons delivery systems, C4I and advanced sensors will force the historically separate Army E3 and EW communities and Army frequency managers to work together. The Army is already using time sensitive, secure networks for most of its information transfer, and it will soon be using such wireless networks as the GIG to provide/receive battlefield information to/from others. Survivability and security will thus become one and the same problem and that problem must not be in the PM's "trade space".

New Technologies and Their Impact on Protection

The Army has an opportunity to select promising new technologies that can counter projected threats against

critical circuits while reducing EM protection costs to PMs. To introduce a timeline into this discussion, consider two time periods in which there are mature EM threats (Table 4 and Table 5): (1) short term (ten years or less), and (2) long term (more than ten years). Ten years was selected since most COTS-based acquisitions typically take ten years or less to be deployed.

Table 4. Short Term (10 yrs or less).

	Net-centric/ Wireless C4I	Increasing EM Threat	Smaller Chip Size	Nano- technology	Unmanned Equipment	COTS	Hardware & Software Protection	DOD Spectrum Sale
Sensitivity	X	X	X		X	X		X
Protection				X			X	

Table 4 category descriptors:

Net-centric/Wireless C4I – The decision to go with a future computer-based C4I system means EW-like, in-band threats (e.g., cyber attack) becomes a major system-level problem – a potential sensitivity

Increasing EM Threat – cyber attacks on military C4I at local and long-range nodes, plus increased E3 warfare on targets of opportunity – a potential sensitivity

Smaller Chip Size – progressively smaller feature sizes (150 nm to 90 nm to 45 nm) lead to lower weight and lower power requirements but could also lead to increased circuit sensitivity (e.g., to single event effects) – a potential sensitivity

Nanotechnology – near-perfect atomic monolayer structures reduce imperfections and enhance reliability; examples include carbon nanotubes and graphene (single-layered sheets of carbon atoms arranged like chicken wire) and are sometimes called “disruptive” technologies – a potential protection

Table 4 and Table 5): (1) short term (ten years or less), and (2) long term (more than ten years). Ten years was selected as the duration for both short and long term, since most COTS-based acquisitions typically take ten years or less to be deployed.

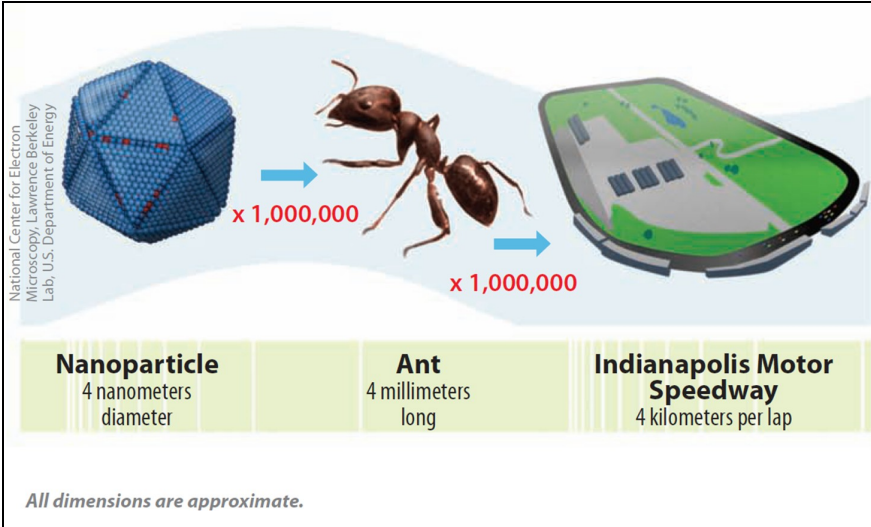
Unmanned Equipment (first and second generation) – sophisticated electronic circuits could replace man-in-the-platform – a potential sensitivity

COTS – the use of electrical components with unknown sensitivity to military environments – a potential sensitivity

Hardware and Software Protection – designing in/maintaining hardware and software protection reduces life cycle acquisition costs - a potential E3 protection

DOD Spectrum Sale – fewer DOD bands require more creative C4I security concepts – a potential sensitivity

In the short term, the use of nanotechnology in circuits will further reduce the size of components while actually hardening them through minimizing lattice imperfections. By combing this technology with the development of security software into new system design, protection costs will be minimized.



Nanoscale materials and effects are found in nature all around us. Nature’s secrets for building from the nanoscale create processes and machinery that scientists hope to imitate. Researchers already have copied the nanostructure of lotus leaves to create water repellent surfaces being used today to make stain-proof clothing, other fabrics and materials. Others are trying to imitate the strength and flexibility of spider silk, which is naturally reinforced nanoscale crystals. Our bodies and those of all animals use natural nanoscale materials, such as proteins and other molecules, to control our bodies’ many systems and processes.

Table 5. Long Term (more than 10 years).

	Integrated EM Threat	Nano-C4I & Sensors	Advanced Unmanned Equipment	COTS Storage Items	Hardware & Software Protection
Sensitivity	X		X		
Protection		X		X	X

Table 5 category descriptors:

Integrated EM Threat – more sophisticated cyber and E3 attacks used by enemies as part of their overall combat plans – a potential sensitivity

Nano-C4I and Sensors – postage stamp microchips that perform as multi-frequency transceivers and sensors with minimal power requirements – a potential protection

Advanced Unmanned Equipment – minimal man-in-the-loop from afar implies advanced onboard circuits must perform increased decision-making on their own – a potential sensitivity

COTS Storage Items– trustworthiness – a potential protection

Hardware & Software Protection – If treated separately, the cost soars; if treated together in the design, the cost diminishes; example: possible quantum mechanical information transfer breakthrough in securing C4I [Further Reading 8] – a potential protection

Long term projections are even more promising. The maturation of short term nanotechnology, plus the application of promising hardware and software protection means future military equipment design will be robust and affordable.

Summary

The EM threat to Army critical circuits is getting more severe, and the traditional approach to protection is no longer the panacea. To cost-effectively address the total EM threat one must now redefine the threat to include the cyber threat and develop a comprehensive approach to EM protection against catastrophic failure, unacceptable upset, and the compromise of secure net-centric wireless C4I. This approach must begin with a change in Army structure that more efficiently oversees traditional and non-traditional protection. A series of observations follow:

1. The modern U.S. Army places increasing reliance on advanced weapon and semiconductor technology as a viable force multiplier, and this trend is likely to continue in the foreseeable future.
2. Future Army C4I will be entirely time-sensitive and secure and will have increased EM protection in order to address the evolving threat. Circuit hardening against traditional EM threats will continue, and software modifications will provide network security.
3. Whereas E3, spectrum management, and EW are presently treated as separate entities in the Army, the most effective and least costly approach to future EM protection will be their integration into one community that addresses all three entities as part of a single technical solution. If done properly, this integration will efficiently emphasize hardware and software protection and will be integrated into a complete, low cost system/subsystem/circuit design.

4. The Army must have a single proponent for all EM/E3 policy issues.

5. Even though the EM threat is evolving rapidly, it is the opinion of the author that the selective use of modern technologies (e.g., nanotechnology) will enhance EM protection and increase the affordability of future military equipment to E3, information attack, and other forms of EM threats [Further Reading 9], even as the list of growing constraints appears to make them more sensitive.

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Further Reading

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Nuclear Power Plants on Military Installations: “A Think Piece”

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Introduction

Historically, the U.S. Army has operated with the assumption that low cost energy would be readily available when and where it is needed. Now, however, reliable access to affordable, stable energy supplies is a significant challenge for the Army and the nation. Given the Army's reliance on energy, disruption of critical power and fuel supplies would harm the Army's ability to accomplish its missions. Such a risk exposes an Army vulnerability that should be addressed by a more secure energy position and outlook. The Army's assumptions concerning future plans for power and fuel at home, overseas and on the battlefield should account for such challenges.

The specific focus of this article is on how nuclear energy can be considered as part of the overall renewable/alternative energy mix, for not just the Army but also for Department of Defense (DOD) installations in general. For the Army, the Army Energy Security Implementation Strategy (AESIS) issued in January 2009 by the Army Senior Energy Council (SEC) and the Office of the Deputy Assistant Secretary of the Army for Energy and Partnerships established five Strategic Energy Security Goals (ESGs). One of these goals, ESG 3, “Increased Use of Renewable/Alternative Energy,” is to raise the share of renewable/alternative resources for power and fuel use, which can result in a decreased dependence upon conventional fuel sources. Alternative Energy is defined in the AESIS as any source of energy (e.g., nuclear, clean coal technologies, hydrogen) that can supplement or replace fossil fuels (oil, coal and natural gas) and other conventional energy sources. This ESG also supports national goals related to renewable/



alternative energy.

The National Defense Authorization Act for Fiscal Year 2010 includes a provision that requires the Secretary of Defense to conduct a study to assess the feasibility of developing nuclear power plants on military installations. In summary, the study shall consider: options for construction and operation; cost estimates and the potential for life cycle cost savings; potential energy security advantages; additional infrastructure costs; impact on quality of life of military personnel; regulatory, State, and local concerns; impact on operations on military installations; potential environmental liabilities; factors impacting safe co-location of nuclear power plants on military installations; and, any other factors that bear on the feasibility of developing nuclear power plants on military installations. Currently, Mr. Brian J. Lally, the Director of Facility Energy in the Office of the Deputy Under Secretary of Defense (Installations and Environment), is the lead for the ongoing feasibility study.

Clearly, as Army Energy Security Implementation Plans (AESIPs) are developed according to the AESIS and the Secretary of Defense conducts a formal feasibility study on

deploying nuclear power plants on military installations, the nuclear energy option for military power and fuel production will likely gain increased attention and may warrant consideration by senior leaders in coming years. The possible renaissance of an Army Nuclear Power Program comes at a time when the commercial nuclear power industry is actively pursuing new nuclear power plants, with 22 combined operating license applications currently under review by the U.S. Nuclear Regulatory Commission (NRC).

Army Nuclear Power Program

In 1954 the Secretary of Defense assigned to the Army the responsibility for developing land-based nuclear power plants required by the three military services. The Army in turn delegated the responsibility for its share of this program to the Chief of Engineers. At that time the Navy was responsible for developing nuclear power for the propulsion of Navy vessels, and the Air Force for developing nuclear power for the propulsion of aircraft. These programs were carried out in close coordination with the U.S. Atomic Energy Commission (AEC). The joint Army-AEC program was known as the Army Nuclear Power Program (ANPP).

The U.S. Army Corps of Engineers (USACE) successfully ran a Nuclear Power Program from 1954 until 1979, primarily to supply electric power in remote areas. The Army built and operated 2 Megawatt electric (MWe) stationary nuclear reactors at Fort Belvoir, Virginia, and Fort Greeley, Alaska. A 10 MWe floating nuclear power plant onboard the *STURGIS* barge supplied electric power at Gatun Lake in the Panama Canal. Portable 1 MWe nuclear reactors were operated at Sundance,



SM-1, Fort Belvoir, Virginia, 1957-1973.

Wyoming; Camp Century, Greenland; and, McMurdo Sound in Antarctica. These small nuclear power plants provided electricity and steam heating for remote military facilities and could be operated efficiently for long periods without refueling. The Army also considered using nuclear power plants overseas to provide uninterrupted power and defense support in the event that military installations were cut off from their normal logistics supply lines.

Other efforts to develop a nuclear power plant small enough for full mobility began as early as 1956, including a gas-cooled reactor design combined with a closed-cycle gas-turbine generator that could be transportable on semi-trailers, railroad flatcars, or barges. The AEC supported these developments because they would contribute to the technology of both military and small commercial power plants. These early efforts had numerous challenges and

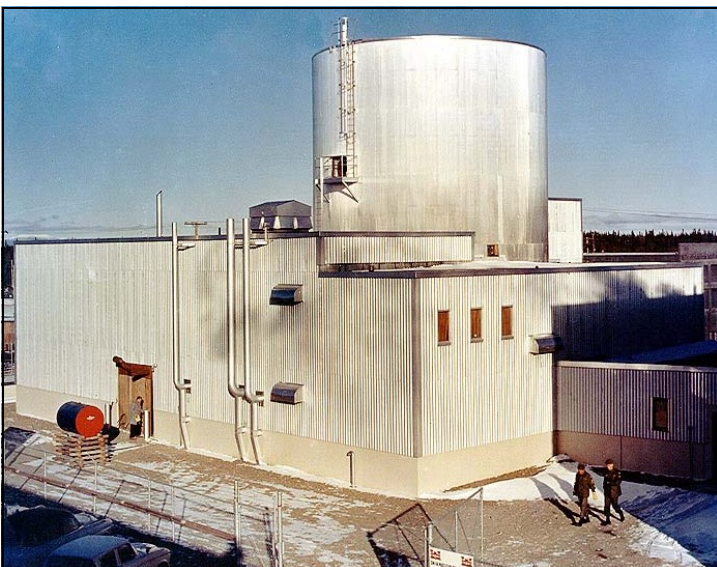
setbacks. For example, the infamous SL-1 boiling water reactor accident at the National Reactor Testing Station at Idaho Falls, Idaho, on January 3, 1961, destroyed the reactor and killed three operators. Several other innovative nuclear plants were designed but never built, including a proposed liquid metal cooled reactor.

The AEC eventually concluded that achieving the ANPP objectives in a timely manner and at a reasonable cost was too difficult to justify continued funding of its portion of projects to develop small, stationary, and mobile reactors. Cutbacks in military funding for long-range research and development because of the Vietnam War led the AEC to phase out its support of the program in 1966. The costs of developing and producing compact nuclear power plants were simply too high without a clearly defined objective backed by the DOD. The Army's participation in nuclear power plant research and development efforts steadily declined and eventually stopped altogether.



MH-1A, *STURGIS*, 1967-1975.

Stewardship of the Army's deactivated reactors after 1979 was maintained by USACE and continued to be overseen by the Army Reactor Systems Health and Safety Review Committee (ARCHS). In 1996, Army Regulation 50-7 established the Army Reactor Program designating the Deputy Chief of Staff G-3/5/7 as the proponent for the program and created the Army Reactor Council (ARC) to replace ARCHS to provide overall executive oversight of Army reactors. In addition to the deactivated USACE reactors remaining at Fort Belvoir, Fort Greely, and onboard the *STURGIS* barge moored at the James River Reserve Fleet, Virginia, the Army continued to operate two fast burst reactors for nuclear effects testing: the Army Pulse Radiation Facility (APRF) at Aberdeen Proving Ground, Maryland; and, the Fast Burst Reactor (FBR) at White Sands Missile Range, New Mexico. The APRF was shut down in 2004 and is currently being decommissioned. The FBR continues to operate. The three USACE reactors will be decommissioned in the future as funding becomes available.



SM-1A, Fort Greely, Alaska, 1962-1972.

The ARC has an oversight role for any new reactor projects. The ARC is responsible for approving proposals for new reactors and sponsoring associated technical studies as required. Therefore, any development of nuclear power plants on Army installations would necessarily require ARC review and approval. Since the Army has not

been involved with any new reactor projects for over 40 years, there are numerous issues that will need to be addressed if senior leaders decide to build and deploy new nuclear power reactors on military installations.

Challenges Ahead for Consideration

A renaissance of the ANPP or similar program would require retracing many of the steps performed in the early 1950's that established the original program. In 1952, the Army Office of the Chief of Engineers (OCE) conducted a DOD study to determine the feasibility of developing reactor plants to serve military power needs on land. In 1953, the report was forwarded to the Joint Chiefs of Staff (JCS) who established the requirement for development of military nuclear power plants. On the recommendation of the JCS, the Secretary of Defense in February 1954 assigned responsibility for the development effort to the Army. The ANPP was then established with two staff elements, one within AEC and the other in OCE, both headed by a single individual appointed by the Army with AEC concurrence. A similar sequence of events (study, recommendation, decision, and implementation) would be required to establish a new program today. DOD would need to determine feasibility, establish a requirement, and assign responsibility for a new program, and that program would then need statutory authority, funding, and staffing to be implemented. The recent legislative provision for DOD to conduct a feasibility study is a good first step towards a new program, but is certainly no guarantee that anything more may happen beyond a study unless all stakeholders are willing and determined to move forward to make it happen.

The AEC has been replaced by the Department of Energy (DOE) and the NRC since Army reactors were last developed in the 1960's. The DOD would need to establish new relationships with these organizations. A Memorandum of Agreement between AEC and DOD dating back to 1967 regarding health and safety responsibilities for DOD reactors acquired pursuant to Section 91b of the Atomic Energy Act of 1954, as amended, remains legally effective. This agreement should be updated to address a renewed DOD/DOE program and NRC safety reviews of new reactor concepts.

New reactor concepts appropriate for military installations will likely involve innovative and unproven designs. The NRC has historically focused on light-water reactor designs and would have to develop new licensing requirements and processes for the new technologies. To meet the statutory requirement of the Energy Policy Act of 2005 to complete construction and operation of the Next Generation Nuclear Plant (NGNP) by FY2021, the NRC estimated in 2008 that it would take 5 years to develop necessary analytical tools, data, and other regulatory infrastructure (e.g., regulatory guides, standard review plan, etc.) for confirmatory safety analyses and license review, and another 4-5 years to conduct the licensing review. DOD may be able to justify a faster safety review process for new reactors under a national security and/or homeland defense priority, but again there is no guarantee that the

NRC would expedite reviews unless all stakeholders are willing to move forward to support the ESGs and other national goals.

Resolving these initial issues alone would simply lay the groundwork for a new ANPP or similar program. There are many more issues to address and resolve to actually build an entirely new program from inception to full deployment and operation. For the focus of this article, it is important to understand that these initial issues should be addressed as part of the DOD feasibility study to ensure that potential deployment of nuclear power plants on military installations can be seriously considered in the future as part of the overall renewable/alternative energy mix. In all likelihood, commercial plants licensed by the NRC to provide dedicated electrical power to military installations via long-term power purchase agreements may be more practical than DOD becoming the owner/operator of new reactors.

Small Modular Reactor Concepts

Several commercial vendors such as Hyperion, NuScale, and General Atomics have been developing small modular reactor (SMR) designs intended to be "power modules" that can be sited individually or ganged together to meet power needs. These reactors are appealing for possible deployment on or near military installations, and they are just a few examples of the many new designs under development. Other designs for deployable tactical power systems are in development. While many of these innovative designs are characterized as "inherently safe," there are still many aspects of their design and operation that require further safety analyses for either military or commercial licensing. A point to emphasize when evaluating possible deployment of SMRs on military installations is that prototype plants could receive expedited safety reviews for construction and operation, and these demonstration plants could then provide useful operating data for more extensive safety reviews required for full commercial licensing.

Hyperion Power Module

Hyperion Power Generation has a compelling 25 MWe liquid-metal cooled fast reactor design that could be very practical for military installations. Like a "nuclear battery," the Hyperion Power Module (HPM) is a compact, transportable unit that can deliver reliable and economically attractive power for about seven to ten years between module replacements. It can be installed in an underground containment vessel, externally monitored, and possibly require a minimal staff of licensed nuclear operator personnel.

The HPM reactor core consists of 24 assemblies of uranium hydride metal fuel enriched to about twenty percent, 18 boron carbide control rods, and a quartz radial reflector. Heat transfer from the 500 degrees Celsius reactor to steam generators on the surface is via heat pipes containing liquid lead-bismuth eutectic coolant. The center of the core contains a void space where boron carbide



Hyperion Power Module.

marbles would be dropped in case of an emergency for safe shutdown.

The HPM is about 1.5 meters in diameter and 2 meters high, comparable in size to a residential hot tub. The compact size, along with the transportability and ease of operation, makes the factory-sealed and self-contained HPM a viable option for providing consistent, reliable, affordable power in remote locations, or alternatively as secure power for large military installations at risk of losing commercial grid power for extended periods of time. Buried underground and out of sight, the HPM presents a minimal security threat and its radiation safely shielded from people and the environment. For further information see their web site at: hyperionpowergeneration.com

NuScale Power Module

NuScale Power, Inc., has developed a modular, scalable design for a 45 MWe nuclear power plant based on known proven technology. Similar to a conventional light water reactor, the NuScale Power Module (NPM) features an integrated reactor vessel enclosed in an air evacuated containment vessel, immersed in a large pool of water and located below grade. The NPM's simple and robust design maximizes safety and security through use of automated systems, modularity, and multiple fission product barriers.

The NPM reactor core consists of 24 17x17 standard UO_2 fuel assemblies six feet in length and enriched to 4.95 percent. It operates at 1500 psig and 300 degrees Celsius with a 24 month refueling interval. Unlike a current plant, the NPM's engineered safety features include a passive decay heat removal system and containment heat



NuScale Power Module.

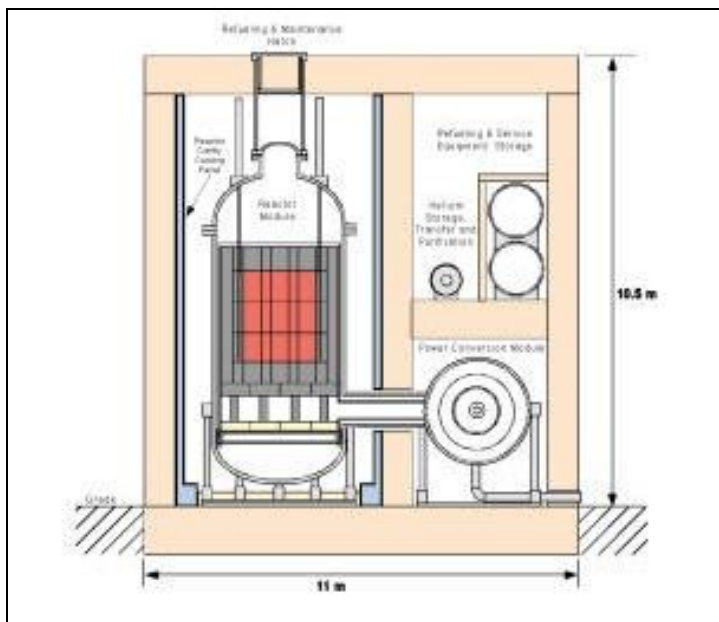
removal system, as well as other severe accident mitigation and prevention design features.

The NPM integrated vessel is about 2.7 meters in diameter and 14 meters high. For all intents and purposes the NPM is still very much like a miniature conventional light water reactor plant complete with a multi-module control room and licensed operator staff. This may be more than most military installations need, but commercially licensed and operated units could be located on or near military installations to provide dedicated electrical power. For further information see their web site at: nuscale-power.com

General Atomics RS-MHR

General Atomics has a design for a gas-cooled reactor coupled to an advanced gas turbine system to achieve high efficiency and small size. The Remote Site – Modular Helium Reactor (RS-MHR) provides steady-state power in the range of 10 to 25 MWe. The RS-MHR can be constructed in about a year and all equipment can be truck transported. The plant can possibly be operated by a small technician staff and the reactor monitored remotely through satellite uplink.

The RS-MHR reactor core consists of standard hexagonal graphite blocks having longitudinal channels for coolant flow and 19.9 percent enriched fuel compacts containing ceramic coated particle fuel. The core contains sufficient fuel for five to ten years of operation without the need for refueling. The ceramic fuel coatings can tolerate temperatures much higher than those postulated to occur during even the most severe accident scenarios and can



General Atomics RS-MHR.

safely retain fission products during both normal and accident conditions. RS-MHR safety is further enhanced by a combination of passive and intrinsic safety features that requires no active safety features or operator action to ensure safe operation and shutdown.

The combination of the modular helium reactor and an advanced gas turbine represents the ultimate in simplicity, safety, and economy. The reactor coolant directly drives the turbine which turns the generator, allowing costly and failure prone steam generating equipment to be eliminated. The result is a simplified power cycle with very high efficiency and reliability, and low power cost. An alternative design for a high temperature gas-cooled Process Steam/Cogeneration Modular Helium Reactor (PS/C-MHR) can provide 950 degrees Celsius process heat for transportation fuel development and hydrogen production for various energy applications. General Atomics is also developing a small gas-cooled fast reactor called EM2 that can be scaled to as low as 25 MWe for military installations.

The entire RS-MHR reactor and power conversion system can fit into two small pressure vessels housed in an above-grade shielded concrete structure mounted on a single 11x10 meter basemat and about 10.5 meters high. Above-grade construction of the facility enables a high degree of siting flexibility, particularly in remote areas with permafrost or high ground water, where construction has to be simple and not require large excavations or heavy lifting equipment. Where cost competitiveness may be more important than the security advantage of underground construction, the RS-MHR or PS/C-MHR could be viable options to meet some military energy requirements. For further information see their web site at: ga.com

Conclusion

The deployment of nuclear power plants on or near

military installations could be a viable solution for the dual problems of escalating energy costs and the increasing security risks of extended electrical grid outages. The DOD feasibility study may well demonstrate the viability of nuclear power for serious consideration as part of the military's future energy mix; however, this would constitute only a necessary first step. Further challenges lie ahead to implement a new program to build and operate nuclear reactors on or near military installations if senior leaders decide to embrace nuclear power. Fortunately, there is a historical precedent to follow. Where the Army successfully used land-based nuclear power once before, the Army could help make it happen again.

Beyond the issue of possibly deploying nuclear power plants on or near domestic military installations, some military planners are already considering the use of deployable nuclear power systems to help satisfy future tactical energy requirements. Nuclear power could be a viable alternative for producing electricity, synthetic fuels, and/or potable water on distant battlefields to reduce the increasingly costly and burdensome logistics requirements needed to sustain our forces abroad. While the foreseeable challenges of implementing a domestic nuclear power program in the near term are formidable enough, the long term challenges of implementing battlefield nuclear power systems are more speculative and uncertain. But again, where the Army once experimented with deployable tactical nuclear power before, the Army could build upon historical precedent to support a future feasibility study in this area.



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USANCA Launches Army CWMD Information Portal (ACIP)

Gerald Barrington
Information Technology Specialist

The creation of the Army CWMD Information Portal (ACIP) will further enable USANCA to be the premier Army organization for exercising coordination, analysis, and integration of Nuclear and CWMD operations, planning, and future capabilities for the Army across Joint and Strategic domains in support of National and DOD objectives. Right now the ACIP is in its infancy but it has already begun to provide the CWMD community with useful information and data regarding Chemical, Biological, Radiological, and Nuclear (CBRN) topics, Nuclear Reactors, CBRN Modeling and Simulation. The USANCA information portal, referred to as ACIP, was developed as a planning resource and resolve the problem of researching CWMD material from many points of references online to avoid replicating existing resources. The portal is intended to reduce or eliminate the time spent sorting through the vast amount of CWMD information available while looking for specific CWMD reference material. The ACIP, when fully populated, will provide the Army's CWMD community with one central point of reference. ACIP has undergone several development iterations and format changes since standing up on the unclassified Army Knowledge Online (AKO) in May 2009 and the formal introduction at the CWMD Conference hosted at USANCA in September 2009.

How can you access it?

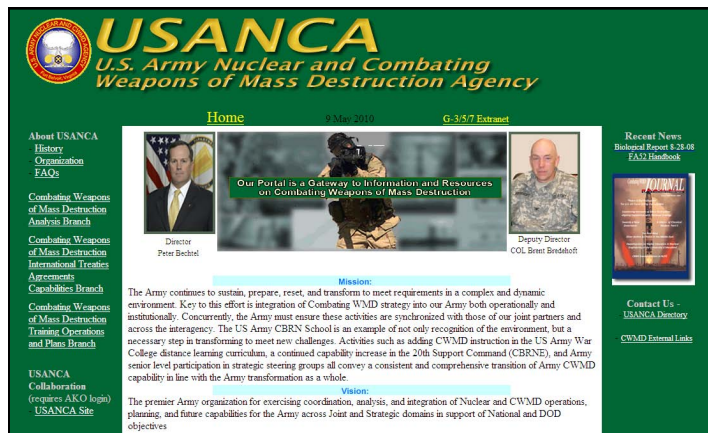
USANCA's initial prototype of the ACIP is currently located in the unclassified Army Knowledge Online (AKO) with the near term intention to provide a classified version in AKO-S. The ACIP can be accessed by doing a search for USANCA in AKO or going to the following URL in AKO: <https://www.us.army.mil/suite/page/481530>.

What does it look like?

The ACIP layout was created with user friendly navigation and content viewing. Visitors navigate thru the individual USANCA Division areas to find information provided by each subject matter expert.

Who are the contributors?

The initial portal information was established by USANCA content managers from the CWMD Analysis Division. These designated subject matter experts from each section of the Analysis Division submitted data to populate the portal and will maintain currency of the content. Other USANCA Divisions will add content and populate their respective web pages in the future.



ACIP front panel user interface.

What's in the ACIP?

The purpose of this service is to improve the way members of the CWMD Community of Interest store and gather information regardless of location. The ACIP is a gathering of CWMD information found at one central location that is readily available. The ACIP provides useful links to other sites that may help with visitor's research and data gathering. The user can find historical information, driving directions and security requirements for visiting USANCA. ACIP is a valuable tool for the CWMD community and Army.



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The Mission that Drove World History – The Manhattan Project –

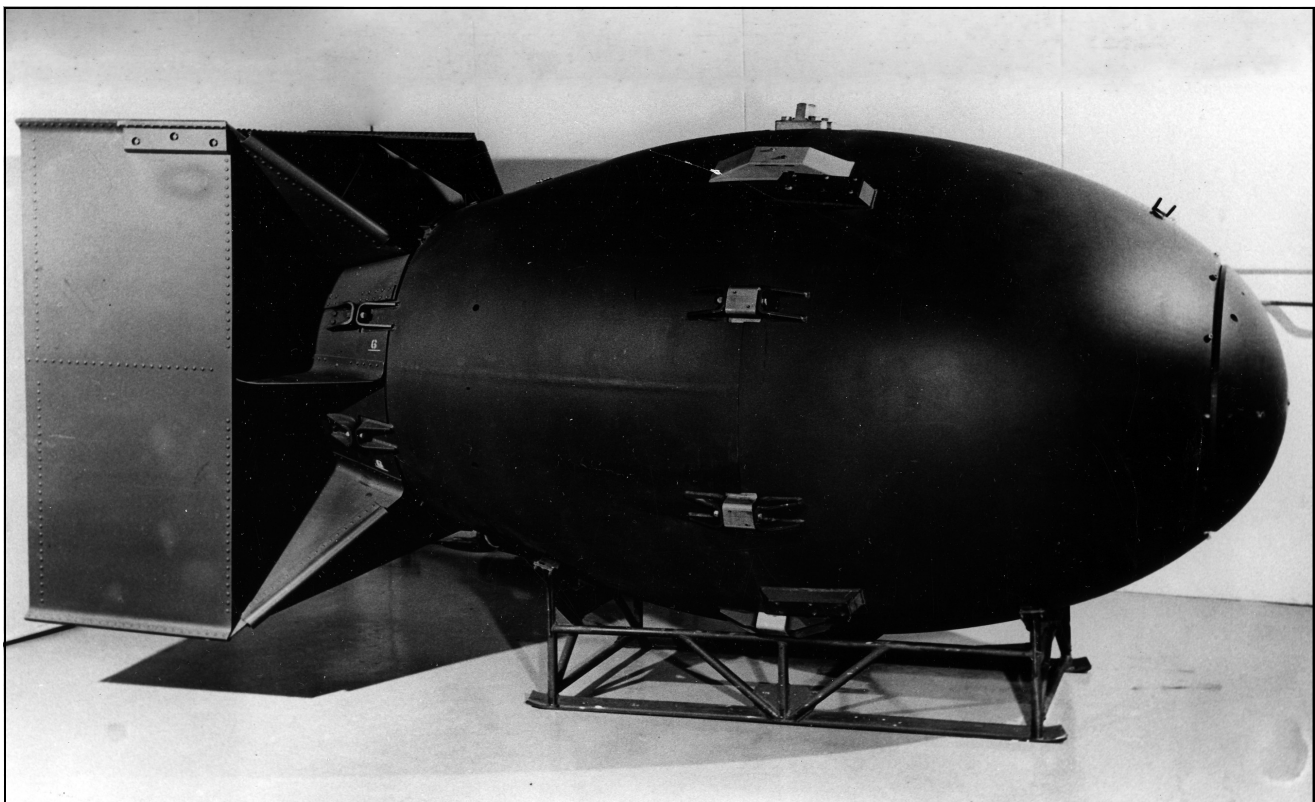
Timothy Joseph, Ph.D.
Technical Writer

Three facts most of us know are: the United States entered World War-II when the Japanese bombed Pearl Harbor, Dec 7, 1941; the war ended when the first weapons of mass destruction ever created were used against Japan in 1945; and the *Manhattan Project* was the undertaking that built those weapons. Beyond that, few truly understand the epic story of that mission. After seeing my recent book: “*Historic Photos of the Manhattan Project*,” The United States Army Nuclear and Combating Weapons of Mass Destruction Agency (USANCA) asked if I would provide a full appreciation of this monumental accomplishment for their readers.

The *Manhattan Project* is justly the most profound endeavor and accomplishment the world has ever known. It was the U.S. response to the undeclared and top-secret race to produce the first weapon of mass destruction

known to humanity. It behooves us all to truly comprehend the full story: the politics of its birth - why we had to win the race - how it took hold and grew incredibly fast - the successes and failures – the dedicate military, scientists, and civilians who were the project - the inconceivable organizational and scientific challenges and accomplishments - the happiness yet sadness of success – the philosophical differenced regarding use of the bombs, and how the project never really ended but continues yet today to give us so much.

Never had so much been accomplished so quickly by so many. The statistics of politics, time, manpower, organization, conditions, and construction were in and of themselves staggering, but equally so was the inconceivable pace in the advancement of science required to make success possible. There never has been, or will be again, a



The plutonium implosion bomb “Fat Man” was just over 10 feet long and 5 feet in diameter, weighing 10,200 lbs. It produced an explosive force of 21,000 tons of TNT, a temperature of 7,000 degrees, and winds of 625 MPH. The mushroom cloud rose to 11 miles.

mission of such intense importance, challenge, and achievement as the Manhattan Project, a single mission that radically drove world history.

To give you the insight and understanding requested by USANCA will require a series of articles, for no single article could possibly do justice. In this initial article I start at the very beginning -- the project's birth: the chaotic politics of a world at war; the scientists that realized the need; the military that took action and moved beyond the impossible; and the perfect teaming of scientists, military, and civilians who brought it about. As we move through this journey, I will highlight the exceptional factors that make this project truly mind-boggling.

Germany invaded Poland in 1939, France and Britain declared war on Germany, and all of Europe was steeped in war. The U.S. Watched closely but stood clear for two years, until the infamous bombing of Pearl Harbor. The extraordinary political circumstances of that time created an unimaginable world threat. The need to act in response to that threat became clear to certain scientists in Europe. More importantly, that chaos provided many of the scientific minds responsible for success of the mission. How? There had been a long, terrible history of German and Jewish conflict, and when Adolf Hitler took power in 1933, there was a mass exodus of scientists and professors from Germany, for they knew his leadership meant loss of freedom, and the beginning of a reign of tyranny. Had those scientists stayed in Germany and been loyal to Hitler, the scientific knowledge needed to succeed would have remained there, and one can only imagine the consequence.

Because those scientists defected (most going to Britain and the U.S.), we knew that Germany was working feverously to split the atom, with the sole purpose of building a horrific weapon of mass destruction. Using the theoretical work of Leo Szilard and Enrico Fermi, Otto Hahn and Friedrich Strassman in Germany bombarded uranium atoms with neutrons in 1938 and said that the nuclei had burst; they wrote a manuscript, which Szilard and Fermi took to Columbia University in Manhattan and indeed found neutron multiplication in uranium. This proved that nuclear fission indeed was possible. Theoretically, if you smashed the uranium nucleus and unleashed all the neutrons, they could in turn smash other nuclei and create an uncontrolled chain reaction of immense energy. Those defected scientists knew the Germans were working on that very process.

Szilard approached his good Jewish friend Albert Einstein and they drafted a letter to President Roosevelt, August 2, 1939, concerned with the work in Germany, suggesting the U.S. move forward quickly before Germany succeeded; thus began the most important race in world history.

Exceptional Factor: Had those renowned scientists not defected, had we not known of the German's progress in using undiscovered physics to create the first

weapon of mass destruction, had that letter of concern not been written, had Roosevelt disregarded the possibility since everything was theoretical anyway, what then? Likely, no project.

Okay. The president believed the threat was real and set the race in motion, but remember, we hadn't even split the atom. With only \$6,000 from the government, Enrico Fermi, Leo Szilard and their team of scientists built a 25 ft wide by 20 ft high crude pile of graphite weighing 771,000 lbs under the abandoned racquet court of the University of Chicago called the Chicago Pile 1 (CP-1). In it they put 80,590 lbs of uranium oxide and 12,400 lbs of uranium metal costing one million dollars, and the rest is history. They created the first controlled nuclear fusion chain reaction. It lasted 28 minutes, produced less than 1-watt of energy, but proved the atom could indeed be split. In doing so they also proved the concept of a nuclear weapon of incredible energy by employing an uncontrolled fusion reaction.

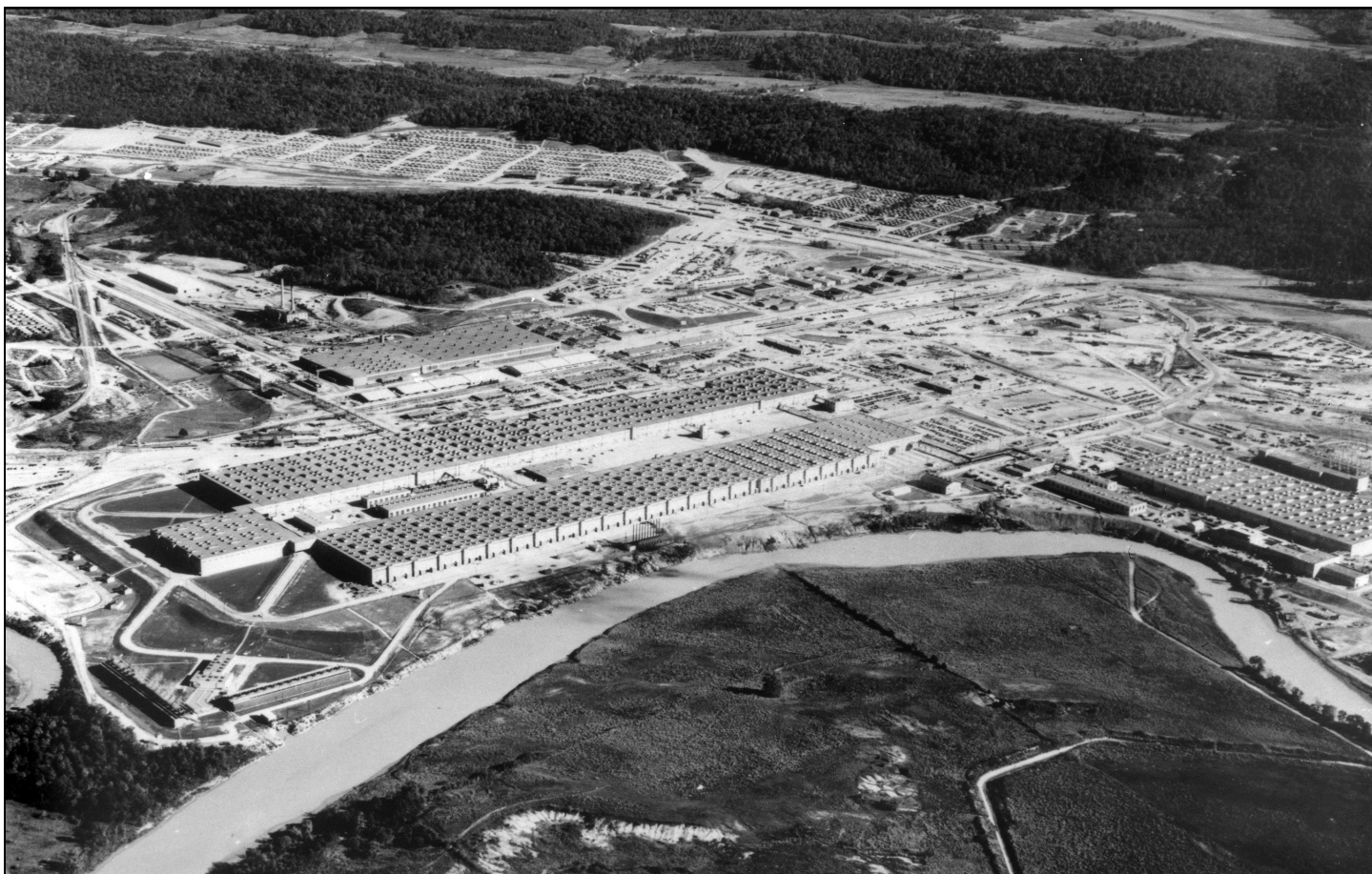
Another critical aspect was the wisdom of the military leader, General Leslie Groves, the director of the Manhattan Project. Why so? Because he was told by his Scientific Director, Dr. Robert Oppenheimer and his scientists, that a bomb is theoretically possible, but it would need lots of highly enriched uranium or plutonium. They explained that three or four laboratory scale processes could produce incredibly small quantities, but it would take massive factories to make enough for a bomb; and oh, if we indeed can



Leslie Groves at the Y-12 site in Oak Ridge, TN, with Secretary of War Robert Patterson and Senator Tom Stewart, Sept 29, 1945.



Manhattan Project workers at Hanford donated their time to purchase a B-17 named Day's Pay for the war effort, and workers at Oak Ridge purchased a B-25 named Sunday Punch.



An aerial photo of the enormous gaseous diffusion building at K-25 in Oak Ridge, nearly a mile long, with the residential area in the background called Happy Valley. 12,000 workers were employed at the site.

make enough, we don't know how to make a bomb with it. The number of scientific and manufacturing unknowns was staggering.

Perhaps the most brilliant decision General Groves made was to take no chances. He decided to go with all possibilities. He told his team to take what little they knew about the four laboratory processes, multiply it by several thousand times, and tell him what he needed to construct the huge facilities to manufacture the amount of highly enriched uranium and plutonium needed. Then he asked what they needed to figure out how to build a bomb with it assuming they could manufacture enough material.

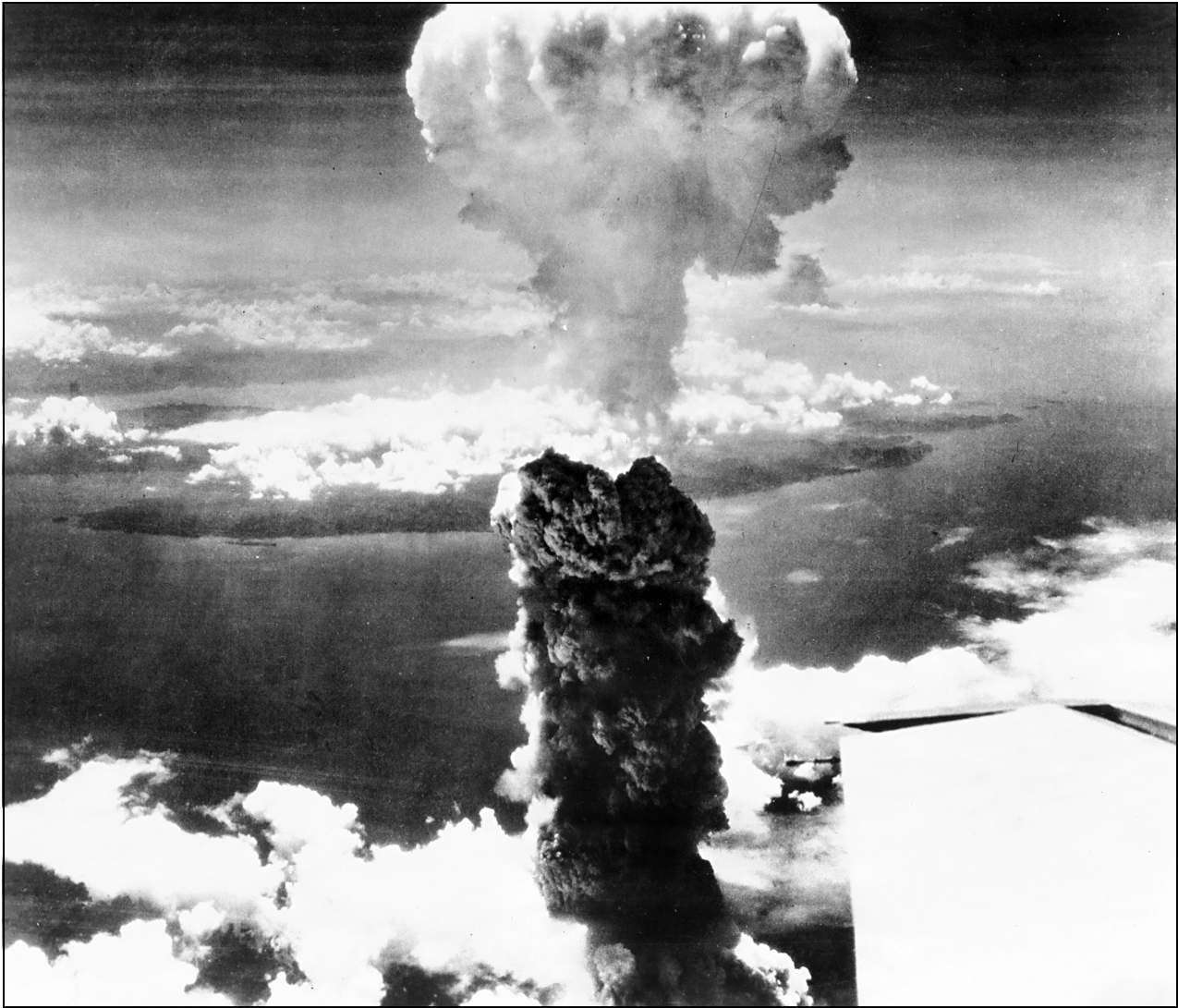
Exceptional Factor: Groves began the construction of massive plants when what was to go inside was unknown, for they were to employ four processes never before proven. He had selected the sites even before the successful first chain reaction of CP-1. He believed the theories of the scientists, had faith in their ability to move from laboratory scale to full scale facilities, and set out new research in how to manufacture large quantities of highly enriched uranium and plutonium as he built the facilities. At the same time, he built a large high explosive research facility to figure out how to build a bomb. Had he waited to determine what would work, had he not started construction

when merely a theory existed, how much longer would the war have lasted? Would we have won the race?

Think about this. It would be unheard of today to even consider something so monumental. Yet before the scientists had any idea how to produce what they needed, Groves kicked off the most massive and incredible project the world has ever known, based on theories and a thousand unknowns with literally no certainty of success. I cannot fathom anyone getting their arms around the number of uncertainties yet going forward with such a massive construction undertaking -- Groves did. Remember, I am not talking small research buildings, but immense factories and facilities with hundreds of support buildings and infrastructure, including huge electric power plants, chemical plants, and giant buildings all to separate tiny isotopes of uranium and make plutonium from uranium.

In Oak Ridge Tennessee, four huge facilities in three different valleys were constructed at the same time.

- Y-12 was constructed to house the electromagnetic process for separating and enriching uranium using Calutrons. There were 13,200 workers and operating force of 22,842 employees.



On August 6, at 8:15 am, the uranium bomb "little boy" was released at 32,000 ft. over Hiroshima and detonated 1,900 ft. Everything within a circle of about two miles was completely destroyed and fires instantly raged across nearly 4.5 square miles.

- K-25 was constructed to separate Uranium isotopes by diffusing uranium hexafluoride gas through porous barriers in the famous nearly mile long U shaped gaseous diffusion building. At K-25 there was a construction workforce of 25,000. It had its own little city called Happy Valley with school and stores.
- X-10 (Oak Ridge National Laboratory) started with the Graphite Reactor for production of Plutonium-239 from uranium so scientists could research and develop chemical and physical methods to separate the isotopes of plutonium. It had a workforce of 3,247.
- The S-50 plant and large power plant were built on the Clinch River, to separate uranium by liquid thermal diffusion. Shortly after it went full-scale it was shut down due to problems and demolished the following year, it was a failure.

Los Alamos, NM, out in the middle of nowhere, Groves purchased a boy's school and soon more than 50 buildings were built to research advanced high explosive research and bomb-design.

Hanford, Washington, large full-scale reactors and huge power plant were built based on the CP-1 design for production of plutonium.

Nearly $\frac{3}{4}$ of the world's supply of mercury was in Oak Ridge, and tons of pure silver was borrowed from the U.S. Mint since the amount needed was not available anywhere else. Towns, schools, shopping areas, theatres, hospitals, residential areas with houses, trailers, hutments, and barracks went up by the thousands to house and support the workers and their families. And remember, this was all going on at the same time in three different remote parts of the U.S. One man, General Groves, and his team of scientists, managed all of this, to turn theoretical physics into the first weapon of mass destruction.



This famous photo taken in Oak Ridge on August 14, 1945 says it all, the war and the killing were over.

If that's not enough of a challenge, here's another amazing fact. Everything researched, designed, and constructed was done with slide rule, pencil and paper, and mechanical adding machines. There were no such things as calculators let alone computers, or PERT or GANT charts, and few engineering drawings were made, for things were being constructed on the fly. Yet simultaneously, in Hanford, Washington, Los Alamos, New Mexico, and Oak Ridge, Tennessee, enormous plants were being constructed.

Let me talk science for a moment. Protons and neutrons in an atom's nucleus are bonded together by incredible amounts of energy. Knowing the number of protons and neutrons in one nucleus, scientists can calculate the energy released when all the bonds are broken. To give you an idea of how much energy that is, if you could release all the energy in all the nuclei of all the atoms in a single Lincoln penny, you could power New York for over a year. I ran that by a physicist friend and he confirmed it.

The major unknown for the project scientists was how many neutrons would be released, and how many of them would strike another nucleus to release more neutrons, and how much uranium or plutonium do you need to use in a bomb since you know all the neutrons will not be re-

leased. They struggled with the answer, and let me just say, they missed the mark considerably, using more nuclear material than needed. There were just too many unknowns about fission and bomb construction.

General Groves and his team of scientists struggled with the following: which processes should be utilized to make highly enriched uranium and plutonium; how to increase laboratory scale methods to full scale factories; how to configure and construct a mechanism/bomb that would produce an uncontrolled chain reaction using uranium and another with plutonium; how much nuclear material should be used; and how to do it all without an accident that could contaminate or take out the city and personnel doing the work. Remember, all of this was unexplored science, most of it theoretical, and yet in three remote areas of the U.S., huge facilities were constructed.

In the next article, I will show you those incredible "People" of the Manhattan Project who actually did the work – the workers and their families. We will look at their sacrifices, their efforts, their pride as Americans, their understanding of secrecy, how they lived and where they worked. We'll take a close look at the primitive tools they had to work with, but with which they accomplished so much, and we'll look closely at the three remote regions

where this all took place. In future articles I will take you to the construction of the two different types of bombs, testing, deployment, the incredible destruction and cost in property and life, the surrender, and the celebration of peace and sadness of defeat. We will look too at the difficult decision and philosophy of using such a weapon, and lastly, I will show you why that incredible project never ended, yet continues to impact our world today in so many positive ways.

In conclusion, let me say this: When the United States entered WW-II, the single goal was to end it. Wars are ended in two ways—killing, and fear of being killed. In just the seven months before the two nuclear bombs were released on Japan, conventional bombing raids had destroyed most of 67 Japanese cities killing hundreds of thousands, yet no end to the war was in sight. Changing conventional bombing raids to two single nuclear bomb drops instilled enough fear in the Japanese to bring about surrender and the end of WW-II. Estimates vary, but as many as 500,000 Japanese died and 5 million made homeless by war's end. Worldwide, more than 70 million people, most of them civilians, lost their lives in WW-II, the deadliest conflict in all of human history. The Manhattan Project ended that conflict.

The honor of achievement belongs to every scientist, military and political leader, and every individual worker involved in the Project. Although the two nuclear bombs ended the war, it did so at a great cost to innocence. I write this paper with utmost respect and sadness for every individual who unwillingly paid the ultimate price of war. Every American celebrated the end of the war and new found peace, yet at the same time shed tears for those innocent Japanese people who died and suffered the consequence of our success. If only wisdom could wipe war from the face of the earth as quickly as were so many innocent souls.



Dr. Timothy Joseph, is a freelance technical writer in Knoxville, TN. He holds a B.S. in Zoology, a B.S. in Education, an M.S. in Biology, and a Ph.D. in Biology/Fisheries. He is a past High School Teacher and College Professor, and Senior Scientist with the U.S. Department of Energy, and he is a published novelist. His email address is timjosephphd@gmail.com

ENDNOTES

These photos are part of the collection of nearly 200 Photographs contained in: "*Historic Photos of the Manhattan Project*," by Dr. Timothy Joseph, Published by Turner Publishing, Nashville, TN. For an autographed copy of the author's new book, "*Historic Photos of the Manhattan Project*," you may contact the author or it can be obtained, unsigned, from any bookstore.



General Leslie Groves (left), military head of the Manhattan Project, with Prof. Robert Oppenheimer (right), scientific head of the project.
Photo: DOE



Manhattan Project Lapel Pin, ca. 1945.
Source: History of Atomic Energy Collection, 0386.

Historical Development of the Nuclear Weapons Accident Response Procedures (NARP)

MAJ W. David Jones

Chief of Doctrine and Joint Lessons Learned

Defense Threat Reduction Agency's Information Analysis Center Albuquerque, NM.

Introduction

On July 16, 1945, the United States (U.S.) detonated the world's first nuclear weapon in Alamogordo, New Mexico. Residents from hundreds of miles away report seeing "two sunrises" that day. The light that fell upon the world that morning ushered in a new era – the Atomic Age. Since the Atomic Age ushered in novel and devastating approaches to modern warfare, safety took on a new meaning. Within a few years, the U.S. had developed a number of different nuclear weapon designs. Weapon designers created a number of different safety features to ensure that a nuclear weapon would not prematurely or accidentally detonate. Many approaches used physical separation of components, but in the earliest days of weapon design, the explosives used in the bombs and warheads were more sensitive. Once disturbed, the weapon could explode, scattering parts over wide areas and releasing expensive radioactive materials in the aftermath. Eventually, engineers and designers produced and tested a number of explosives; after thorough testing and examination under a variety of conditions, several types were adopted.

During the maturing days of the Atomic Age, a number of accidents involving U.S. nuclear weapons occurred that required domestic and foreign military and government civilians to respond quickly. Since 1945, history records a total of thirty-two nuclear-weapon accidents in the United States. While details of many of these accidents remain classified, the accidents of yesteryear encouraged early emergency response plan-



ners to develop procedures in the event that a nuclear weapon was damaged in an accident. The net result after almost three decades of accident response was the Department of Defense (DoD) 3150.8-M, also commonly referred to as the Nuclear Weapons Accident Response Procedures (NARP) manual. This article will describe in some detail the development of the NARP from an unclassified, historical basis.

Feasibility Study

The NARP was authorized by DoD Directive 3150.8. That directive created the first version of the NARP, which until 1999 was administered as DoD 5100.52-M. In 1999, the manual was changed to the current DoD 3150.8-M.

In its almost 30-year history, the NARP underwent a plethora of changes. From earliest records available at the Defense Threat Reduction Agency's Defense Threat Reduction Information Analysis Center (DTRIAC) at Kirtland Air Force Base, New Mexico, the DoD executed a feasibility study authored by Major

Dennis K. Maj Dakan, USAF, entitled "Joint Nuclear Accident Response" under the supervision of the Air Command and Staff College to develop a manual. This culminated in a document produced in the summer of 1977. The feasibility study made the following statements:

A nuclear weapons accident occurring in the U.S. may require response by several federal agencies, two or more military services, and state and local government agencies. The federal agencies and military services have published directives pertinent to nuclear weapons accident response and recovery operations. The purpose of this research project is to investigate federal agency and military service directives to ascertain the feasibility of developing a joint program for nuclear accident response. These directives are examined for commonality and mutually exclusive requirements concerning clear accident response. The author concludes that a joint nuclear accident response program is feasible.¹

The feasibility study indicates a need to prepare a set of procedures that may be used by military and civilian first responders to mitigate the effects of a nuclear weapon accident. Maj Dakan, was assigned to the Interservice Nuclear Weapons School at Kirtland AFB, NM, recognized that a severe problem existed in the joint community regarding interservice cooperation at a nuclear weapons accident site. Prior to the author detailing this research, there were no standardized procedures that all four services adhered to when dealing with this sensitive issue. As a participant of Palomares incident in Spain,

Maj Dakan noted several serious accidents occurring in the past and recognized that a lack of standards extended across all the services prevented a more timely response effort.²

Maj Dakan identified several key issues which he thought were paramount to addressing a solution:

1. To determine the specific intent of the relevant DoD implementing instructions.
2. To determine specific requirements of each military service in responding to nuclear weapons accidents.
3. To determine commonality and exclusive service requirements pertaining to nuclear accident response.
4. To recommend a plan of general response actions that could be accepted as a joint regulation/instruction for each service.³

These issues would form the basis for the remainder of the document.

Maj Dakan relates the creation of the Atomic Energy Commission and the DoD as part of his statement of the problem; in his research, the two agencies provided very little mutual cooperation. The creation of the Defense Atomic Support Agency (which eventually became the Defense Threat Reduction Agency) helped somewhat, but there was no unifying entity that had studied or created a document that brought together all of the support agencies that had been or would be involved in mediating a nuclear weapon accident. The services and a number of agencies had signed a mutual aid document entitled "Joint Department of Defense and Atomic Energy Commission Agreement in Response to Accidents Involving Radioactive Materials" in 1966; the agreement spelled out roles and responsibilities of a large number of agencies, but it lacked the authority to enforce guidance. This omission was added in a Joint Memorandum signed in 1970. The Defense Atomic Support Agency was renamed the Defense Nuclear Agency in 1971, and the Atomic Energy Commission was replaced by both the Energy Re-

search and Development Administration (ERDA) and the Nuclear Regulatory Commission; with these agency changes in place, the Joint Memorandum began to specify more detailed roles and responsibilities. In addition, three specific memoranda were written to empower agencies regarding nuclear weapons accident response: DoD 5100.52, DoD 5230.16, and DoD 7730.12.

DoD 5100.52 instructed the following:

1. Guidance to the military services and Defense Nuclear Agency for planning and providing radiological assistance in the event of a radiological accident;
2. Assignment of DoD responsibilities for participation in the Interagency Radiological Assistance Plan (IRAP); and
3. Confirmation of DoD responsibilities in the Joint DoD-ERDA Agreement - Response to Accidents Involving Radiological Materials.⁴

DoD 5230.16 added information regarding the role of public affairs. The instruction dictated that the DoD would make a prompt release of information to the public in the interest of maintaining safety and to prevent panic and chaos. It also instructed units responsible for transporting nuclear materials to create detailed manifests and contingency plans.⁵

DoD 7730.12 mandated prompt reporting to officials at the National Military Command Center in the event of a nuclear weapon accident or incident, and it also established procedures that units would use in such an event.⁶

Maj Dakan's suggestions and comprehensive research were incorporated using all of these instructions, plus a number of interagency and interservice ideas to form the first comprehensive nuclear weapon accident response manual in 1983.

1983 NARP

The first version of the NARP had

a total of 154 pages, cover to cover. It had eighteen sections, and was developed by the field command of the Defense Nuclear Agency, which is the predecessor of the Defense Threat Reduction Agency.

The 1983 version outlined specifics in many areas, including the responsibilities of government agencies, command and control, radiological safety and health physics, communications, security, medical, weapons operations, public affairs, logistics support, legal, site restoration, a summary of specialized capabilities, training, and general references.⁷

1984 NARP

The second version of the NARP had a total of 164 pages, cover to cover. It had seventeen sections, and was developed and published by the Defense Nuclear Agency.

The 1984 version spelled out the purpose of the NARP:

This manual provides a consolidated summary of procedural guidance, technical information, and Department of Defense responsibilities to assist DoD forces in preparing for nuclear weapon accident response in the United States. It is intended to assist the on-scene commander and his staff in directing the recovery from a nuclear weapon accident. The information contained herein is intended specifically for use in responding to a DoD nuclear weapon accident within the United States and its territories and possessions.⁸

The 1984 NARP outlined specifics in many areas, including the responsibilities of government agencies, responsibilities of other agencies, management of accident response, radiation safety and environmental monitoring, communications, security, medical, weapons operations, public affairs, logistics support, legal, site restoration, a summary of specialized capabilities, training, and a list of agreements, directives, publications, and general references.⁹ The 1984 NARP was a more detailed revision, and included a significantly increased number of diagrams, tables, and technical references, especially re-

garding dosimetry and health-physics related information.

The 1984 version of the NARP lasted a number of years before a revision and published again in 1999. In the meantime, the Department of Energy (DOE), the Defense Special Weapons Agency (a predecessor of the Defense Threat Reduction Agency and the agency that replaced the Defense Nuclear Agency), and the Joint Nuclear Accident Coordinating Center created an additional supplement to the NARP called the "Nuclear Accident Response Capability Listing," or NARCL. The first NARCL was published in 1995, and a revision was published in 1997. The NARCL listed agencies, their radiation detection and monitoring equipment, and point-of-contact telephone numbers in the event that a nuclear weapons accident or incident occurred within the continental United States (CONUS). Outside CONUS listings were also included in the event that host nations requested US assistance for accidents occurring overseas.¹⁰

1999 NARP (DoD 3150.8-M)

A monstrous document, the 1999 version of the NARP was double the content of its predecessor at 388 pages from cover to cover. This hefty document included chapters on the following areas: nuclear weapons accident response procedures, shipboard accident response (new), radiological hazard and safety environmental monitoring, respiratory and personnel protection (new), contamination control, bioassay procedures (new), radioactive materials, characteristics, hazards, and health considerations (new), conversion factors for weapons-grade plutonium (new), medical, security, weapon recovery operations, communications, public affairs, legal, logistic support, training, overview of the site-remediation process (new), accident science response (new), intermediate actions (new), long-term actions (new), summary of specialized capabilities, and a bibliography. The 1999-version had a significant number of appendices at the end of most chapters. Of note was a point-of-contact listing for major DoD

and non-DoD organizations involved in accident response.

The 1999 3150.8-M was the first truly extensive manual designed to bring the interagencies together to mitigate a nuclear weapon accident or incident. The manual was divided into four major parts: Planning, Policy, and Response Guidance; Technical and Administrative Issues of Radiological Response; Site remediation Guidance; and Specialized Assets and Points of Contact. This NARP was designed to help the reader pinpoint very specific information quickly and efficiently. The manual contained an even greater number of illustrations than the 1984 version, which assisted the reader (commander, staff officer, or student) in visualizing how to set up a national defense area, tactical operations centers, media relations and other outlets, and how to tackle the accident site itself. The 1999 version was, at that time, one of the most complete technical manuals in DoD inventory.¹¹

2005 NARP (DoD 3150.8-M)

The 2005 NARP took a step backward by reducing information, decreasing to 344 pages cover to cover. Major subdivisions and chapters were deleted or made into substantially smaller appendices.

The 2005 NARP contained chapters on: functional response tiers and nuclear weapon accident response assets and resources; US territory nuclear weapon accident response phase I: notification and deployment; US territory nuclear weapon accident response phase II: initial response; US territory nuclear weapon accident response phase III: accident site consolidation; US territory nuclear weapon accident response phase IIII: weapon recovery operations and disposition; US territory nuclear weapon accident response phase v: site remediation; shipboard accident response; foreign territory US nuclear weapon accident response concept of operations; radiological hazard and safety environmental monitoring; medical; security; communications; public affairs; legal; logistic support; and training.¹²

Future Versions of the NARP

A new version of the NARP is currently under review and expected to be released later this year. The Defense Nuclear Weapons School and other agencies have received copies for comment. These additional changes may help the NARP become more user-friendly. In its history, the NARP, which started out as an Air Force Air Command and Staff student's project, has become one of the founding documents upon which the Defense Threat Reduction Agency is based. Its usefulness as doctrine is proven, and has become an essential tool in many of the classes held at the Defense Nuclear Weapons School, which is part of the Defense Threat Reduction University.

The NARP has changed since its beginnings, and no doubt will continue to change, so long as the world faces threats from nuclear powers and terrorists. As long as the U.S. has nuclear weapons as part of its defense strategy, the NARP will live on, and commanders and staffs across the planet will be required to understand the clean, proven, scientific doctrine found in its pages.

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ENDNOTES

1. Joint Nuclear Accident Response Feasibility Study. Maj Dennis K. Dakan, USAF, Air Command and Staff College, May 1977.
2. Ibid.
3. Ibid.
4. DoD 5100.52, dated 1971.
5. DoD 5230.16, dated 1971.
6. DoD 7730.12, dated 1971.
7. Nuclear Weapons Accident Response Procedures. 11 March 1983.
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Sea Power

Deterrence from the Sea

CW5 Stephen A. Gomes
Nuclear Targeting Officer
United States Army Nuclear and CWMD Agency

This is the final article highlighting some of America's nuclear arsenal during the Cold War era. America's nuclear sea power has been a part of our extended deterrence from that era and continues into the present. The first article, "*Tactical Nuclear Weapons in the Cold War Era... A Blast from the Past*" discussed the United States (U.S.) Army's nuclear arsenal. These tactical nuclear weapons allowed the Land Component Commander highly flexible response options consisting of terrain obstructing atomic demolition munitions, artillery fired atomic projectiles (AFAP), and long range guided missiles; the second article, "*Peace is our Profession*" highlighted the U.S. Air Force's Strategic Air Command (SAC) responsibility for nuclear deterrence through manned bombers, cruise missiles and intercontinental missiles and their ability to strike globally. This article will chronicle some of the nuclear weapons the U.S. Navy employed to keep the peace and freedoms of the sea the world has come to know.

The mission of the U.S. Navy is to maintain, train and equip combat-ready Naval forces capable of winning wars, deterring aggression and maintaining freedom of the seas.

Mission statement of the United States Navy

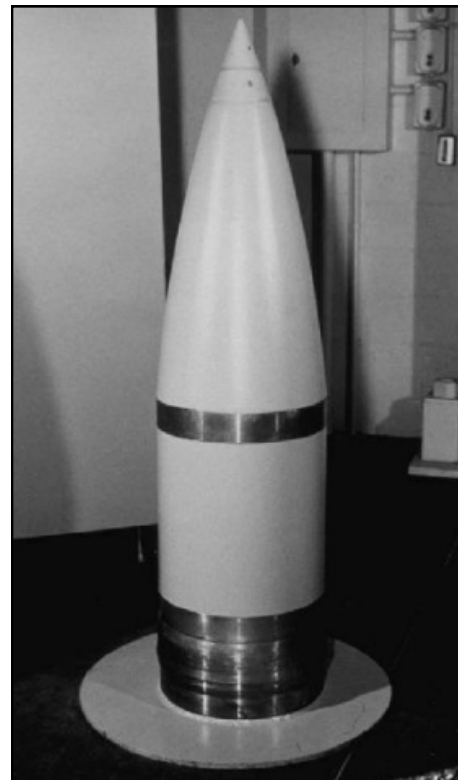
From their simple mission statement, there are a variety of underlying and complex supporting missions. The support missions were many, to include air defense of the fleet, anti submarine warfare (ASW) and global strike mission, that not only supported the fleet, but the U.S. nuclear enterprise as a whole as the third leg of our TRIAD.¹ These missions continue today, but some nuclear weapons employed then have been withdrawn as the weapons systems were retired, removed or in some cases replaced with conventional weapons.

What I have not adequately captured in my previous articles are the sheer destructive powers of these nuclear warheads. How does a nuclear warhead with a yield of 10 kilo tons (kt) that's 10,000 tons, compare to conventional explosives? Figure 1. illustrates this point by comparing conventional ordnance to its nuclear siblings. As you can see if we want conventional strike equivalence, we are going to be striking a target for a very long time and with a lot of ordnance. Imagine trying to remove a tree stump in the middle of a field with a small hatchet or one stick of dynamite. The tree stump can get removed with either method; it just depends on how quickly you want that tree

stump removed and what resources you have at hand to remove the stump.

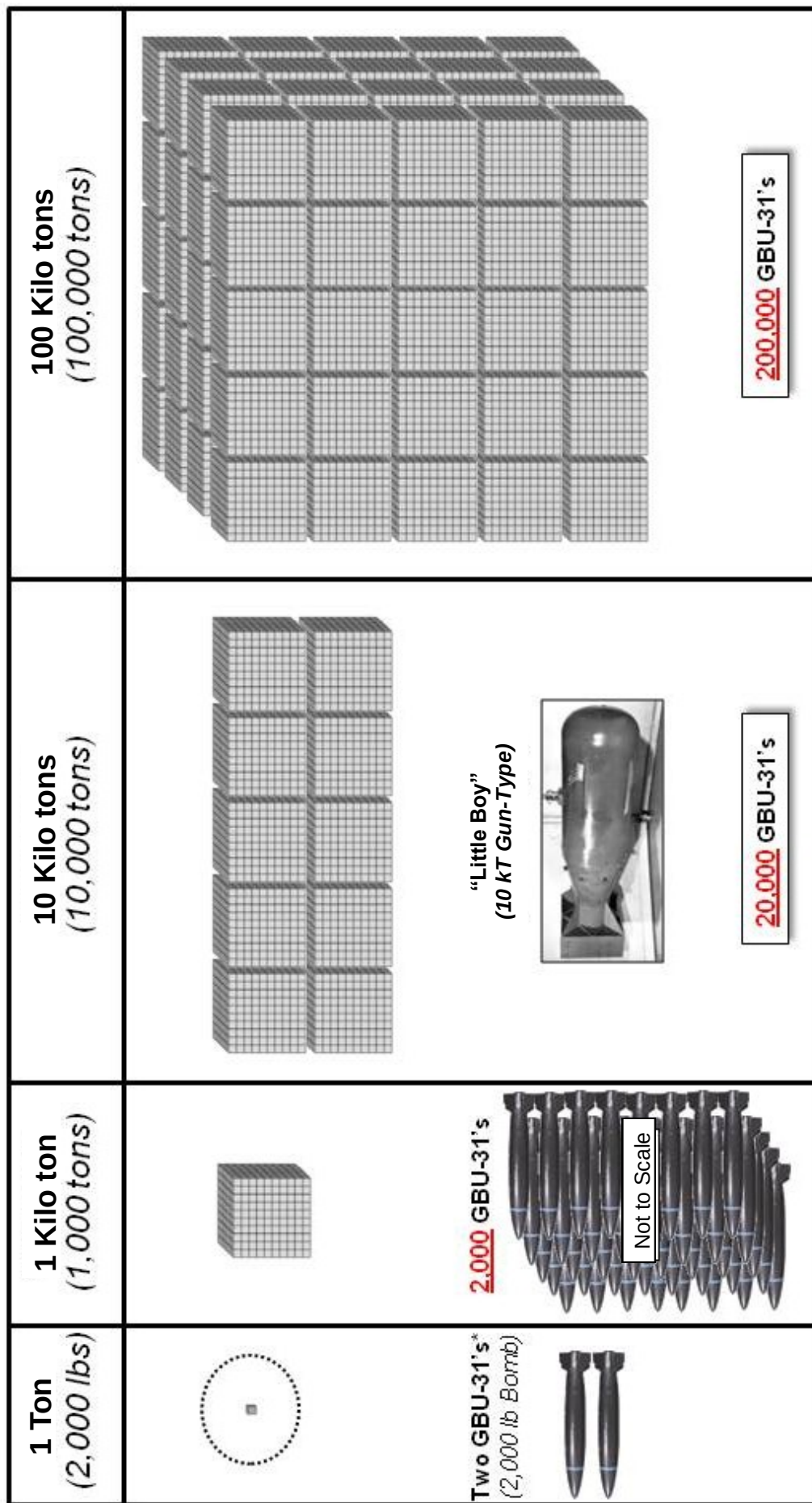
Atomic Projectiles

The U.S. Navy during the Cold war still had battleships in their inventory. Some were mothballed but for those awaiting another combat patrol, their guns were formidable. The Second World War era battleships armed with 16" guns were impressive enough, but they did not escape nuclear armament. The 16' guns could fire conventional 2700 pound armor piercing (AP) shells capable of penetrating over 27 feet of concrete and more than 32 inches of side armor plate. In addition to the standard conventional high capacity (HC) and AP shells, the battleships could deliver atomic projectiles. The Mark 23 atomic warhead could strike targets at distances over 25 miles. This varied basic load of ammunition ensured both nuclear and conventional fire support missions to ground operations.



Photograph by: Department of Energy

Conventional vs. Nuclear



UNCLASSIFIED

* NOTE: One 2,000 lb GBU-31 (JDAM) has about 1,000 lbs of HE (½ ton)

Figure 1. Conventional versus Nuclear

Fleet Air Defense

Air supremacy whether it is on land or sea serves as a hedge to protect our deployed fighting forces. The air defense of the fleet is vital to survival of the ships at sea. This lesson learned from the Second World War demonstrated that the survivability of the fleet depended on the defeat of inbound enemy aircraft. Many surface and sub-surface vessels were damaged, destroyed or sunk from aircraft that breached air cover or the fleet's defensive armament. Once inside, the aircraft can do considerable damage in a short amount of time. Today this threat is not only aircraft, but high speed anti-ship missiles. The U.S. Navy began a series of tests and developments for anti-aircraft missiles under Operation Bumblebee after World War II. The importance of Operation Bumblebee was to design missiles that could provide a mid level of defense from air attack between carrier aircraft and anti-aircraft guns. Among the U.S. Navy anti-aircraft weaponry in their arsenal were the RIM-2 Terrier, and the Talos nuclear missiles.

RIM-2 Terrier

The Convair RIM-2 Terrier was a two-stage medium-range naval surface-to-air missile (SAM) designed for the air defense role as a development from the Bumblebee Project. It was among the earliest SAM systems to equip U.S. Navy vessels built during the 1960s. It could be installed on smaller ships rather than the larger and longer-ranged RIM-8 Talos.

Initially, the Terrier used radar beam-riding guidance, wing control, conventional warhead, and had a top speed of only Mach 1.8, with a range of 10 nautical miles (nm). The short relatively short range and speed made it useful only against subsonic targets. Due to emerging technology and newer requirements, it had major improvements

before it was even in widespread service. The wings were replaced with fixed strakes, and the tail became the control surface, it used a newer motor pushing it to a higher speed (Mach 3), with extended range, and improved maneuverability. The RIM-2D Terrier BT-3A (N) (Beam-riding, Tail control, series 3 Nuclear) used the W45, a 1kt nuclear warhead; all other variants used a conventional warhead.²



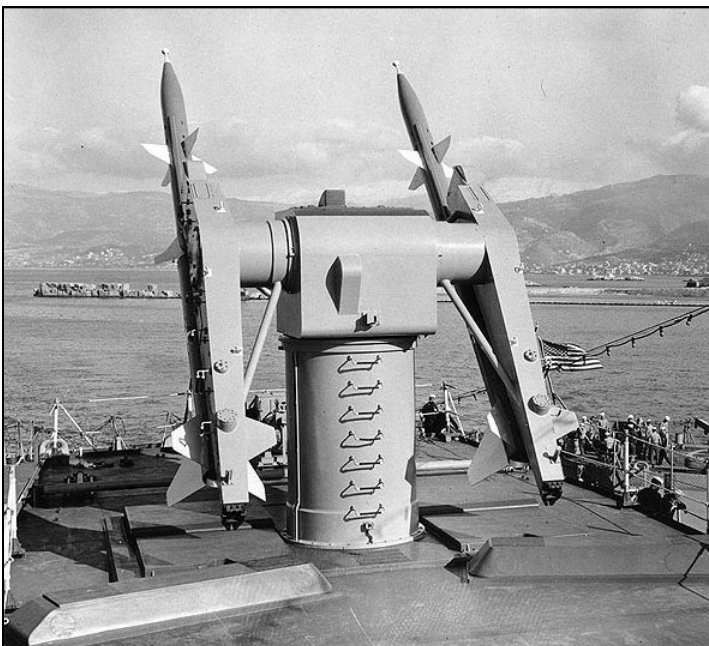
Bendix RIM-8 Talos Surface to Air Missile
Photo: U.S. Navy

Talos

The Bendix RIM-8 Talos was also a development of the Bumblebee SAM Project. The Talos saw limited use due to its large size and few ships could accommodate the system. The size and weight of the missile was similar to jet fighter aircraft of the time.

Talos was a long-range naval SAM missile using radar beam riding for guidance to the vicinity of its target, and semi-active radar homing (SARH) for terminal guidance. Thrust was provided by a solid rocket booster for initial launch and a Bendix ramjet for flight to the target. The characteristic design of the Talos is the arrays of four SARH receiver antennas surrounding the nose of the Talos missiles and the warhead doubling as the ramjet's compressor.

The initial Talos RIM-8A had an effective range of approximately 50 nm, and a conventional warhead. The Talos RIM-8B was a RIM-8A with a W30 nuclear warhead. The RIM-8D was the nuclear warhead version of the Talos RIM-8C, an improved missile having doubled its original range. The Talos RIM-8E "Unified Talos" utilized a warhead that could be exchanged with a nuclear warhead while under way at sea. This model eliminated the need to carry dedicated nuclear warhead only variants. Interestingly, the Talos missile also had surface-to-surface capabilities. The nuclear variants were employed from 1959 to 1979. The Terrier and Talos missiles were replaced by the extended range RIM-67 Standard missile.³



Convair RIM-2 Terrier . Photo: U.S. Navy

Cruise Missiles

Cruise missiles are different than a submarine launched ballistic missile (SLBM), as they use a turbofan engine for propulsion and are much smaller in size and delivery yield than SLBMs. Cruise missiles delivered by U.S. Navy vessels are launched through vertical tubes on surface vessels or via torpedo tubes in submarines and have a short range compared to ballistic missiles. Ballistic missiles use a solid fuel rocket motor and have a short duration of powered flight but much greater range using terminal speed and velocity to strike their targets.⁴

Regulus

The first submarine missile program was "Regulus," the forerunner of the Tomahawk cruise missile. The submarine-launched, subsonic, turbojet-powered Regulus missiles were specifically designed to carry nuclear warheads. The diesel-electric submarine type used for Regulus were submersible ship guided (SSG), later when the submarine fleet began to use nuclear propulsion; the acronym was further modified to SSGN to denote nuclear.

Regulus I was first launched at sea in March 1953 by the converted USS Tunny (SSG-282), housing two missiles in a pressurized hangar. The missile had a range of about 500 nm. By mid-1958, USS Grayback (SSG-574) and USS Growler (SSG-577) had been commissioned as the first purpose-built Regulus submarines, each carrying two in a large bow hangar. At that time, the Navy had four SSGs and four missile-carrying cruisers at sea.

USS Halibut (SSGN-587) was the first nuclear powered submarine specifically designed to carry and launch missiles. Commissioned in January 1960, the USS Halibut could carry four Regulus II missiles in a hangar integral with the hull. Regulus submarines could only prepare and fire their missiles on the surface, then dive to periscope depth to guide the missile to the target. This proved to be



Regulus I firing off the deck of the USS Los Angeles (CA135). Photo: U.S. navy

a critically limiting factor, as the Regulus had a very noticeable back blast from the surface launch.

Regulus II was an improvement over Regulus I, flying at supersonic speeds at Mach 2 and a range reaching 1,200 nm, nearly almost twice as Regulus I. Production of Regulus was phased out in January 1959 with delivery of the 514th missile, and removed from service in August 1964. Regulus provided the first nuclear strategic deterrence force for the U.S. Navy during the early years of the Cold War, and would be the forerunner of the Tomahawk cruise missile.

The Regulus designed and manufactured by Chance Vought was 30 feet long, with a wingspan of 10 feet, a diameter of 4 feet, and would weigh between 10,000 and 12,000 pounds, containing either the W5 or the W27 nuclear war head.⁵



BGM-109 Tomahawk in flight. Photo: DoD

BGM-109 Tomahawk

The BGM-109 Tomahawk is a medium to long-range, all-weather, low-altitude subsonic cruise missile. There are several variants of the Tomahawk employing various types of warheads, with the most notable as the Tomahawk Land Attack Missile or simply TLAM. The Tomahawk was a replacement to the Regulus and is a dual purpose cruise missile armed with a conventional high explosive warhead or W80 nuclear warhead. The nomenclature of a nuclear armed variant is modified to Tomahawk Land Attack Missile – Nuclear or TLAM-N.

The TLAM is launched through a torpedo tube and rises to the surface, deploying small wings then starts the turbofan engine. The small size of the TLAM gives it a low radar cross section and its low-level flight profile makes it difficult to intercept. The TLAM is launched on a preset course initially then later in the flight profile switches to other navigating systems to guide the missile to its target

with excellent accuracy. The Tomahawk was originally designed and manufactured by General Dynamics, with some manufactured by McDonnell Douglas, now all are manufactured by Raytheon.⁶

Anti Submarine Warfare (ASW)

ASROC

ASROC is the acronym for Anti-Submarine ROcket an all-weather, all sea-conditions anti-submarine system developed by the U.S. Navy in the 1950s and deployed in the 1960s. Upgraded with improvements, it is still used by the U.S. Navy on cruisers, destroyers, and frigates and on warships of other nations.

When a surface ship, patrol plane or anti-submarine helicopter detects an enemy submarine by sonar and/or other sensors, it relays the sub's position to an ASROC-equipped ship for attack. The ship would fire the ASROC, an unguided rocket carrying an acoustic homing torpedo or a nuclear depth bomb (NDB) toward the target. At a pre-determined point on the rocket's trajectory, the payload separates from the missile and deploys by parachute to permit a soft water entry at a low speed with minimum detectable noise. The water entry activates the torpedo, and guided by its internal sonar system, homes in on the target using either active or passive sonar.

In cases where the ASROC carried an NDB, the unguided bomb would quickly sink to a predetermined depth where it would detonate. The nuclear variant of the AS-



SUBROC after leaving the water.

Photo: U.S. Navy

weapon. A planned successor, the UUM-125 Sea Lance, was delayed due to funding problems and eventually canceled.

SUBROC was launched from a submarine torpedo tube, similarly like that of the Tomahawk cruise missile. After launch, the solid fuel rocket motor ignited and SUBROC would rise to the surface. The launch angle then changes and SUBROC traveled to the target following a predetermined ballistic trajectory. At a predetermined time in the trajectory, the reentry vehicle containing the warhead separates from the solid fuel motor section. The warhead, a W55 nuclear depth bomb, drops into the water, rapidly sinking before exploding in proximity to its target. A direct hit was not necessary, as the pressure from the explosion would rupture the sub's hull.

SUBROC's approach was not detectable by the target in time to take evasive action, the warhead yield would make evasive maneuvers pointless. SUBROC was less flexible in its use than ASROC since its only payload was a nuclear warhead and no plans were made to convert SUBROC with conventional high explosive warheads. SUBROC was decommissioned following the end of the Cold War in 1989.⁸

Torpedoes

The ASTOR is the acronym for the Mark 45 Anti Submarine TORpedo. The ASTOR was designed for high-speed, deep-diving enemy submarines. The electrically-propelled 19-inch torpedo was 227 inches long and weighed 2,400 pounds. The torpedo had a range of 5 to 8 miles and utilized the W34 nuclear warhead. The torpedo had no internal homing capability; all guidance, target tracking, and detonation was provided by control wire from the launching submarine as a positive control measure for nuclear warheads of this design. Development of ASTOR was completed in 1960 and it entered service in 1963; by 1976 the Mark 45 was withdrawn from service.⁹

Bombs and Depth Charges

Mk 101 "Lulu"

The Mark (Mk) 101 Lulu was developed in the 1950s as an air delivered nuclear depth bomb utilizing the W34 nuclear warhead.



Destroyer USS Agerholm fires an ASROC with a nuclear depth bomb in the "Swordfish" test in 1962.

ROC carried the W44 nuclear warhead. The nuclear armed weapons were removed from deployment and retired by 1989.⁷

SUBROC

SUBmarine ROcket is the acronym for the UUM-44, a submarine-launched rocket intended as an anti-submarine weapon with the U.S. Navy. Its development began in 1958, and by 1965 the U.S. Navy began receiving the new



Mk 45 ASTOR

Photo: Author's collection

It was deployed by the U.S. Navy for anti-submarine warfare, in five different models, from 1958 until 1971. These weapons could be used by U.S. and NATO maritime aircraft such as the Royal Air Force Avro Shackleton aircraft, and Dutch Navy P-2 Neptune and P-3 Orion aircraft. The Mk-101 "Lulu" was replaced by the multi-purpose B57 nuclear bomb in the mid-1960s.

The danger of this weapon was the lack of any type of accelerometer (speed sensor) safeties. If the weapon accidentally fell off an aircraft parked on a flight deck and rolled overboard it could detonate when it sank to the preset depth. The weapon would not detonate at a preset depth if these safeties were incorporated into the design. The design of the safeties could differentiate between high speed free fall from an aircraft, and the slower bomb sink rate from a fall.¹⁰

B-57

The B-57 was a bomb that could be used by tactical strike aircraft in a land warfare role, as well as the nuclear depth bomb role. The B-57 could be deployed by most U.S. fighter, bomber and Navy antisubmarine warfare and patrol aircraft (S-3 Viking and P-3 Orion), and by some U.S. Navy helicopters including the SH-3 Sea King. The B-57 could also be used by Canada's CF-104s.

Entering production in 1963 as the Mk 57, the bomb



B-57 Dual purpose tactical Bomb.

was designed for high-speed tactical aircraft. It had a streamlined body to withstand supersonic flight. The B-57 was also equipped with a parachute retarder to slow the weapon's descent, allowing the aircraft to escape the blast at altitudes under 200 ft. A hydrostatic fuze was utilized for the depth charge role in anti-submarine use.

The B-57 was produced from 1963 to 1967. After 1968, the weapon became known as the B-57 rather than the Mk 57. The B-57 was produced in six versions, and over 3000 weapons were built, the last of which was retired in June 1993.¹¹

Mk 90 "Betty"

The Mk 90 Betty was a nuclear depth charge developed in 1952 as an anti-submarine weapon. It utilized a Mark 7 nuclear warhead. All weapons had been retired and withdrawn from service by 1960.¹²

Guided Ballistic Missiles

In the mid 1950s, the National Security Council (NSC) requested an Immediate Range Ballistic Missile (IRBM) for the defense of the United States. This was in part a measure for deterrence to the missile development by the Soviet Union. The NSC directed that part of this missile force must be sea-based. The Secretary of the Navy created the Special Projects Office (SPO) to work this new requirement. The SPO was tasked with adapting the liquid-fueled Jupiter IRBM for shipboard launch. The Jupiter was originally an Army missile designed for land-based operation. Liquid propellants required strict and careful handling, and it was difficult on land, let alone to be adapted to shipboard use. As a result of these limiting safety and handling factors the U.S. Navy began a parallel effort to the U.S. Air Force to develop safer solid-fuel rocket motors.¹³

Further improvements to solid fuels, smaller and more powerful motor technology, electronic and manufacturing technology reduced the size of the launch platform. Also improved missile guidance, and reentry body (RB) assemblies produced the first true SLBM.

The first solid-fueled missile incorporating this new technology was the Polaris missile. The first submarine launch of a Polaris occurred in July 1960 from the USS George Washington. Three hours later a second missile was successfully launched. These two shots marked the beginning of sea-based nuclear deterrence for the U.S.

New Technology– New Mission, New Nomenclature

The U.S. Navy classifies their vessels by a unique hull classification system. For a nuclear-powered, ballistic nuclear missile-carrying submarine the classification is SSBN. The SS denotes a "submersible ship", B denotes "ballistic missile," and the N denoting "nuclear powered." In U.S. naval parlance, ballistic missile submarines are called "Boomers". Submarines in general are also referred to as "boats" while surface vessels are ships.

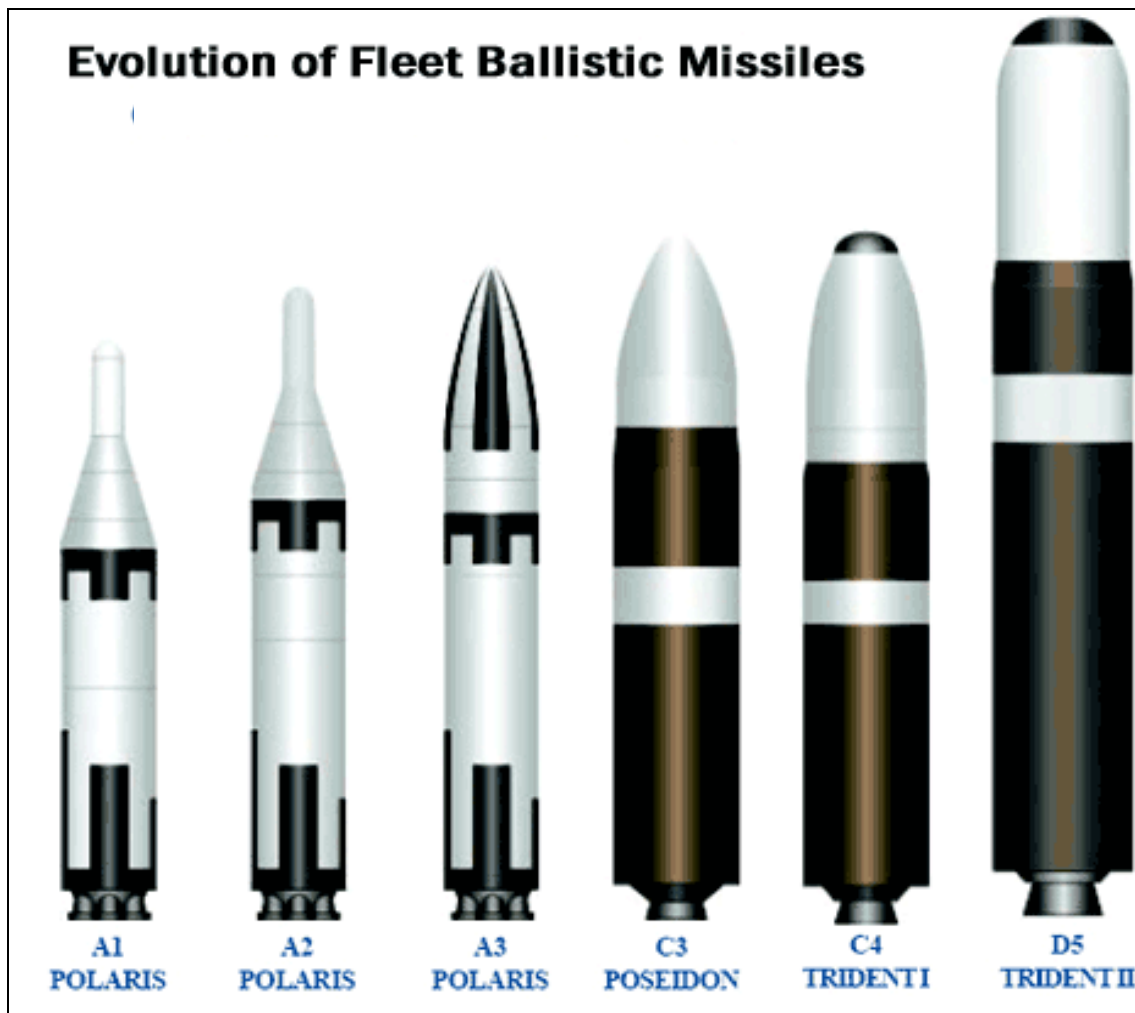


Image: U.S. Navy.

Fleet Ballistic Missile Submarines

Since the 1960s, strategic deterrence has been the SSBN's sole mission, providing the U.S. with its most survivable and enduring nuclear strike capability. The Navy's fleet ballistic missile submarines serve as an undetectable launch platform for intercontinental missiles. They are designed specifically for stealth and the precision delivery of nuclear warheads.

Ohio class SSBNs have the capability to carry up to 24 submarine-launched ballistic missiles (SLBMs) with multiple independently-targeted warheads. The SSBN's primary weapon, the Trident missile, was built in two versions. The first generation missile, Trident C-4, has been phased out of service and replaced by the larger, longer-range, and more precise Trident II D-5. The first eight submarines (SSBN 726 to 733) were initially built to only carry the C-4 missile. The first four Ohio class (SSBN 726 through SSBN 729) ended their strategic deterrent mission in the early 2000s when they began the conversion process into guided missile submarines, or SSGNs. SSBN 730 through 733 have been retrofitted to carry the D-5 missile. SSBN 734 to 743 were designed from the beginning to carry the D-5 missile and continue to execute their primary mission of strategic deterrence. All pre-Ohio class

submarines were retired in 1995.¹⁴

Submarine Launched Ballistic Missiles a Chronology

Polaris.

The Polaris program began in 1957 from the prime contractor Lockheed, now Lockheed Martin for all three versions. The program ended in 1968 after more than 1,400 missiles had been built. The Polaris A-1 missile served as a strategic asset. The missile was developed to complement the limited number of medium-range systems deployed throughout Europe. As those systems lacked the range to attack major Soviet targets, Polaris was developed to increase the level of nuclear deterrence. At this time there was little threat of counterforce strikes, as few systems had the accuracy to destroy missile systems. The primary advantages of ballistic missile submarines were their ability to launch submerged, which offered improved survivability for the submarine.

The first version, the Polaris A-1, had a range of 1000 nautical miles (nm) and a single Mk 1 re-entry body (RB), carrying a single W-47 nuclear warhead, using an inertial guidance system and was deployed from 1960 to 1974. The two-stage solid fuel missile had a length over 28 ft, a body diameter over 50 in, and a launch weight nearly

29,000 lbs. The later versions (the A-2, A-3) were larger, weighed more, and had longer ranges than the A-1. The range increase was improved: The A-2 range was 1,500 nm, the A-3 2,500 nm, and the B-3 2,000 nm. The A-3 featured multiple W-58 RBs which spread the warheads over the target area. The A3, W58 variant was deployed from 1964 to 1982. The Polaris missile and associated nuclear warheads are all retired from U.S. service.¹⁵

UGM-73 Poseidon

The Poseidon missile was the second ballistic missile system deployed by the U.S. Navy. The Poseidon used a two-stage solid fuel rocket and the W68 nuclear warhead. It replaced the Polaris missile beginning in 1972, major advances in nuclear warhead yield and increased accuracy. Originally a planned improved model of the Polaris (B-3) was dropped and the new missile was designated Poseidon C3 to emphasize the technical advances over its predecessor. The Poseidon was only constructed in a single model with the designation UGM-73A. Poseidon had a 2,500 nm range, greater payload capacity, improved accuracy, and multiple RB capability. Poseidon could deliver the W68 thermonuclear warhead to multiple targets. The Poseidon was replaced by Trident I in 1979, and Trident II in 1990.

Global Strike

Trident Series of Missiles a Short Primer

The Trident series had two variants known as Trident I (C4) UGM-96A and the Trident II (D5) UGM-133A. There is no direct relationship between Trident I and II missiles, for example upgrading a common launch platform or improving a rocket motor. The C4 and D5 designations put the missiles within a class or "family" started in 1960 with Polaris A1, A2 and A3 and continued with the Poseidon C3 in 1971, but that is where the similarities end. The Trident I, sometimes referred to as EXPO (Extended Range Poseidon), was an improved version of the Poseidon C-3 missile; the Trident II D-5 however incorporates a completely new design technology and warhead.

Trident I (C4) SLBM

The Trident I is a three-stage, solid fuel, inertial/stellar-guided, SLBM utilizing the W76 nuclear warhead. It had a range of about 4,000 nm. It is a multiple independently-targeted RB system and was originally deployed on the Lafayette-class and early Ohio-class (Trident) submarines. The Trident I missile was initially deployed on modified Poseidon submarines with updated fire control equipment beginning in 1979. The Trident I had increased range and accuracy over the Poseidon missile. The updated weapon system included many improvements resulting from electronic technology. The Trident I was phased out in the 1990s and early 2000s.¹⁶

Trident II (D5) SLBM

The Trident II is a three-stage, solid fuel, SLBM that utilizes the W88 warhead. It has an improved range of over the Trident I. The Trident II uses the latest electronics for improved reliability and maintainability and built with im-

proved materials. The Trident II is deployed on the Ohio-class submarines, starting in 1990 and continues to be deployed today. The Trident II missile booster is also provided to the United Kingdom (U.K.). The U.K. utilize their own warheads on the missiles and deployed on Vanguard class submarines.¹⁷

Conclusion

Unfortunately we cannot be "nuclear free" for some time to come, a fanciful dream but not practical. Since Pandora's Box opened up she's not likely to close any time soon taking all of the design secrets with her. Nuclear warheads of any design and yield are truly the most destructive devices ever conceived by man.

In our lifetime and the years beyond, it is hoped that the fictional order given in the movie, "Crimson Tide" by Captain Ramsey (Gene Hackman), will never be issued:

*"This is the Captain. Set condition 1-SQ for strategic missile launch. Spin up missiles one through five, and twenty through twenty-four. The release of nuclear weapons has been authorized. This is not a drill."*¹⁸



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ENDNOTES

1. TRIAD: A nuclear triad refers to a nuclear strategy consisting of three components: 1. Strategic bombers (armed with bombs or missiles), 2. Land-based missiles (intercontinental missiles (ICBMs)), and 3. Ballistic missile submarines (SSBNs). The purpose of having a TRIAD nuclear capability is to significantly reduce the possibility that an enemy could destroy all of a country's nuclear forces in a first strike attack. The design of the TRIAD ensures a credible threat of a second strike, and increases a nation's nuclear deterrence.
2. http://en.wikipedia.org/wiki/RIM-2_Terrier
3. http://en.wikipedia.org/wiki/RIM-8_Talos
4. Air University Primer U.S. Missile Systems
5. http://www.olive-drab.com/od_nuclear_slbm.php, http://en.wikipedia.org/wiki/SSM-N-8_Regulus
6. *ibid*
7. http://en.wikipedia.org/wiki/RUR-5_ASROC
8. http://en.wikipedia.org/wiki/UUM-44_SUBROC
9. http://en.wikipedia.org/wiki/Mark_48_torpedo
10. [http://en.wikipedia.org/wiki/Mk-101_Lulu_NDB_\(Nuclear_Depth_Bomb\)](http://en.wikipedia.org/wiki/Mk-101_Lulu_NDB_(Nuclear_Depth_Bomb))
11. http://en.wikipedia.org/wiki/B57_nuclear_bomb
12. http://en.wikipedia.org/wiki/Mark_90_Betty_nuclear_bomb
13. *ibid*
14. http://www.navy.mil/navydata/fact_display.asp?cid=4100&tid=200&ct=4
15. http://en.wikipedia.org/wiki/UGM-27_Polaris
16. *ibid*
17. *ibid*
18. Fictional order from the movie "Crimson Tide", 1995 directed by Tony Scott, produced by Don Simpson and Jerry Bruckheimer, written by Michael Schiffer and Richard P. Henrick.

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Simultaneously, the *CWMD Journal* is available at an unrestricted alternate website courtesy of the Chemical, Biological, Radiological & Nuclear Defense Information Analysis Center (CBRNIAC). This website has a wealth of subjects and hosts our current and previous issues at the following link:

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Although this is the last *Journal* that I will perform the Graphics and Layout assignment, I will continue as the Editor and provide continuity for a future replacement. I have certainly enjoyed working the technical aspects of the *Journal* publishing process.

If you would like to contact USANCA please e-mail or write to us at our new address.

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Combating WMD Resource Page



Theater Nuclear Operations Course (TNOC)

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Nuclear and Counterproliferation Officer Course (NCP52)

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

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

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Pandemic Influenza Overview

This class describes influenza types, variations, and effects, and identifies worldwide threats from pandemic influenza. The course examines U.S. strategy to combat the spread of pandemic influenza, identifies organization and responsibilities to implement countermeasures to pandemic influenza.

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U.S. Nuclear Policy

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

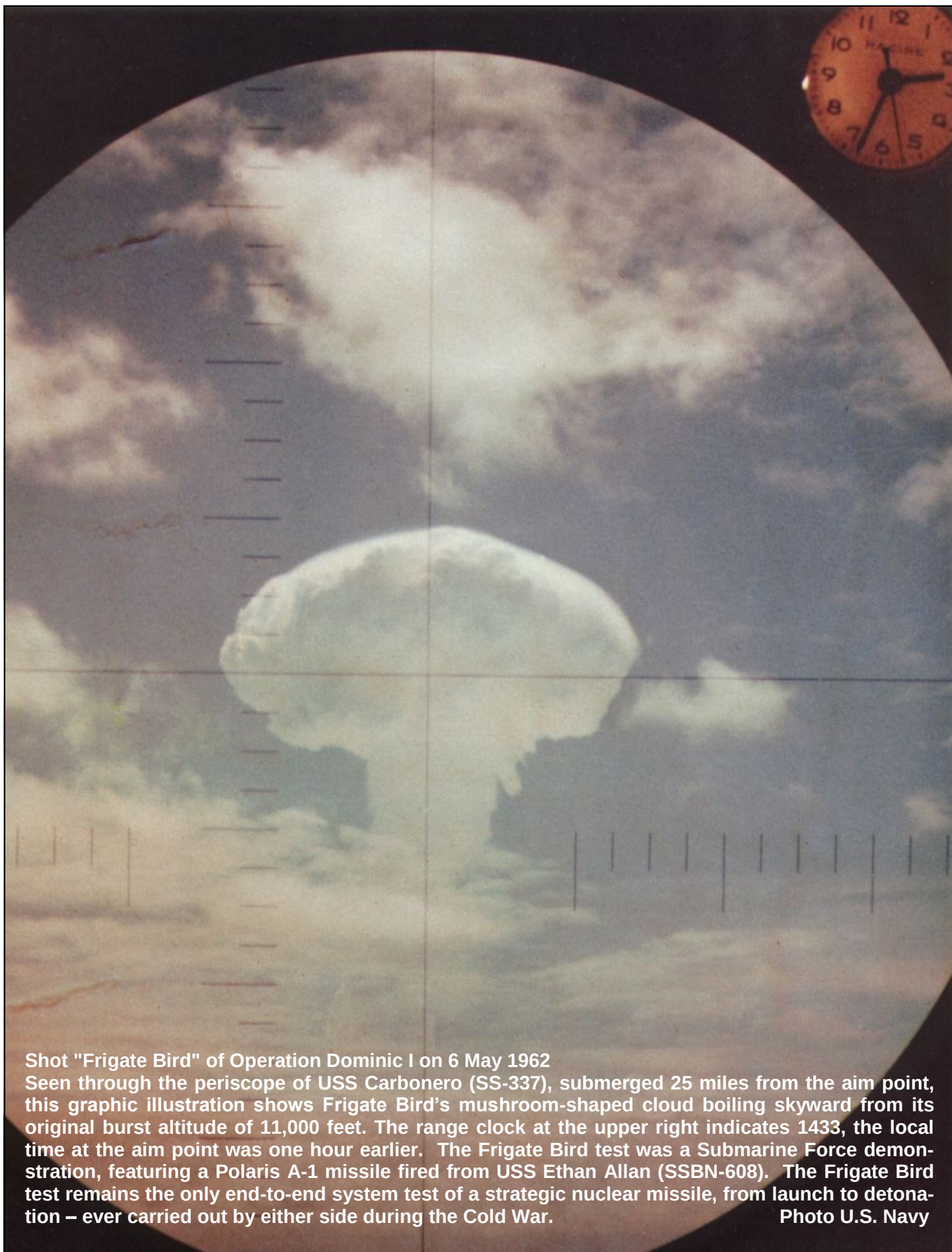
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Shot "Frigate Bird" of Operation Dominic I on 6 May 1962

Seen through the periscope of USS Carbonero (SS-337), submerged 25 miles from the aim point, this graphic illustration shows Frigate Bird's mushroom-shaped cloud boiling skyward from its original burst altitude of 11,000 feet. The range clock at the upper right indicates 1433, the local time at the aim point was one hour earlier. The Frigate Bird test was a Submarine Force demonstration, featuring a Polaris A-1 missile fired from USS Ethan Allan (SSBN-608). The Frigate Bird test remains the only end-to-end system test of a strategic nuclear missile, from launch to detonation – ever carried out by either side during the Cold War.

Photo U.S. Navy

