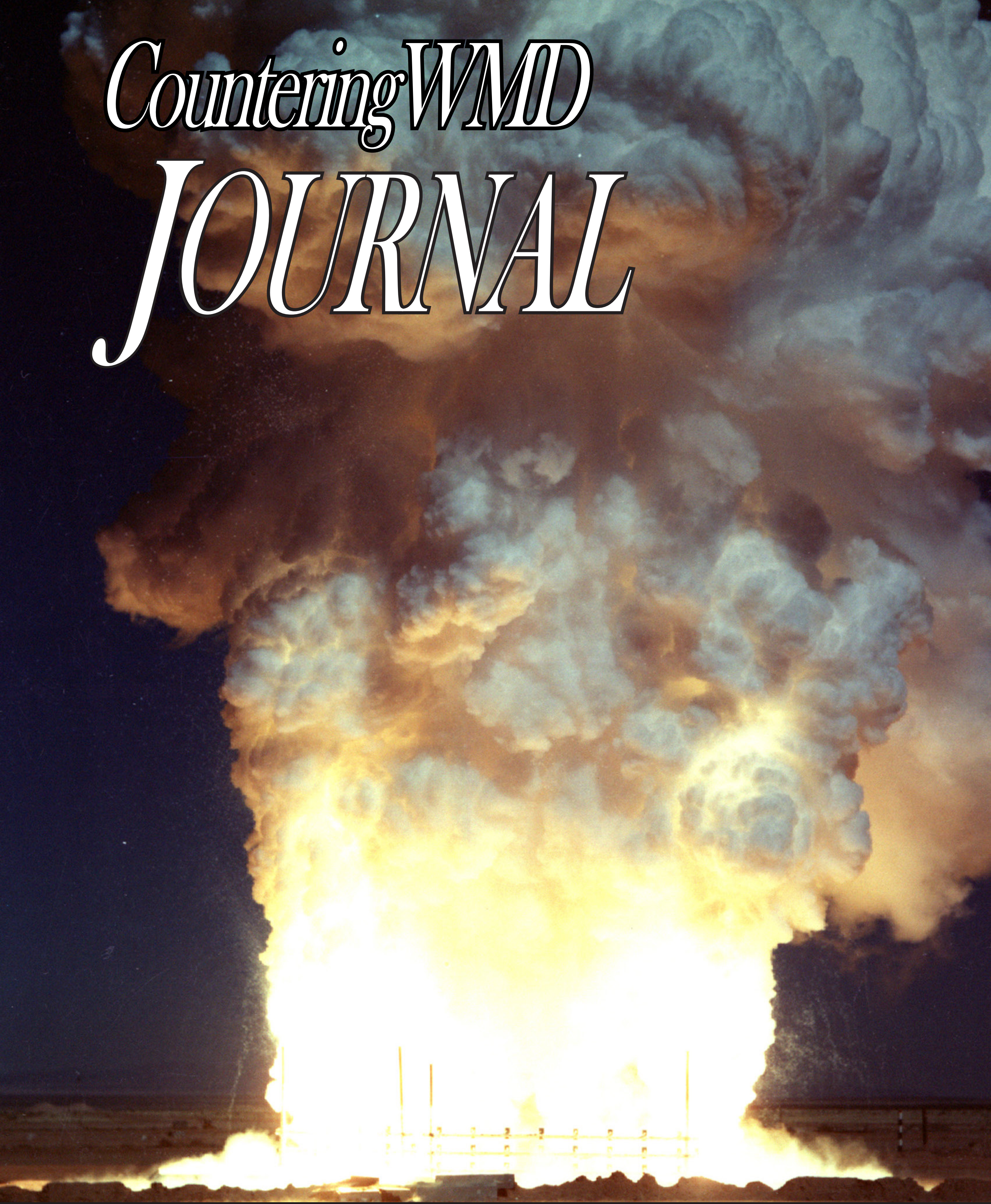
Countering WMD JOURNAL



Issue 18 • Winter/Spring 2019

U.S. Army Nuclear and Countering WMD Agency

REPORT DOCUMENTATION PAGE	*Form Approved OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
05-2019	Semiannual Publication	Winter/Spring 2019

4. TITLE AND SUBTITLE
Countering WMD Journal
Issue #18 Winter/Spring 2019

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Articles submitted by: COL Weidner, John; Mr. Kinman, Bret; MAJ Hardy, Brad; CPT Vanderlip, Joe; Dr. Quiter, Brian; Dr. Pavlovsky, Ryan; LTC Thomas, Benjamin; MAJ Lerch, Andrew; Mrs. Jiles, Heather; Dr. Davis, John; Dr. Seiler, Steven; COL Emmert, Dennis; Mrs. Walker, Anita; COL Plante, Dirk; LTC Kling, Joseph; Mrs. Marshall, Sarah; MAJ Mihal, Christopher; MAJ Bosley, William; Mr. Hamilton, Drew

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Nuclear and Countering Weapons of Mass Destruction Agency (USANCA)
5915 16th St., Bldg. 238
Fort Belvoir, VA 22060-0529

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Nuclear and Countering Weapons of Mass Destruction Agency (USANCA)
5915 16th St., Bldg. 238
Fort Belvoir, VA 22060-0529

10. SPONSOR/MONITOR'S ACRONYM(S)
USANCA

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
U.S. Army organizations and activities with CWMD-related missions, to include all combat and material developers and units with chemical and nuclear surety programs, and FA 52 officers. Distribution Statement A: Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
Countering WMD Journal is peer-reviewed and published semi-annually by the United States Army Nuclear and Countering WMD Agency (USANCA). The Countering WMD Journal focuses on the technical, operational, and policy considerations of nuclear and Countering WMD operations.

15. SUBJECT TERMS
Countering Weapons of Mass Destruction (CWMD); Nuclear Weapon Effects, Nuclear Operations, CWMD Operations, Counterproliferation, Non-proliferation

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
U	U	U	UU	56	MAJ Christopher Bolz
					19b. TELEPHONE NUMBER *(Include area code)* 703-806-7875

Reset

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18
Adobe Professional 7.0

Countering WMD JOURNAL
U.S. Army Nuclear and Countering WMD Agency

Published by the
United States Army Nuclear and Countering WMD Agency
(USANCA)

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Distribution Statement A: Approved for public release; distribution is unlimited.

The Secretary of the Army has determined that the publication of this periodical is necessary in the transaction of the public business as required by law. Funds for printing this publication were approved by the Secretary of the Army in accordance with the provisions of Army Regulation 25-30.

Article Submission: We welcome articles from all U.S. Government agencies and academia involved with CWMD matters. Articles are reviewed and must be approved by the Countering WMD Journal Editorial Board prior to publication. Submit articles in Microsoft Word without automatic features, include photographs, graphs, tables, etc. as separate files. Please call or email us for complete details. The editor retains the right to edit and select which submissions to print. For more information, see the inside back-cover section (Submit an Article to Countering WMD Journal) or visit our website at http://www.belvoir.army.mil/usanca/.

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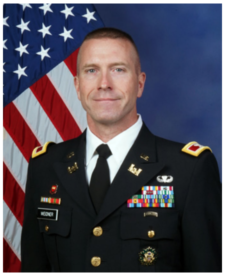
Subject line: ATTN: Editor, CWMD Journal (enter subject)

About the cover: The Large Blast/Thermal Simulator (LBTS) Thermal Radiation Source (TRS). Capable of generating thermal fluxes up to 60 cal/cm^2-sec, the TRS is undergoing restoration after being dormant since 2009. When complete, the LBTS will be able to qualify Army combat vehicles to combined blast and thermal environments representative of nuclear weapon detonations. White Sands Missile Range is conducting the restoration with Defense Threat Reduction Agency support.

Inside the Journal

Director Notes

COL John W. Weidner
Director, USANCA



We have transitioned into the most consequential time for strategic deterrence, CBRN defense and CWMD missions since the end of the Cold War. Consider these recent events:

- On February 13, 2017, two women killed Kim Jong Nam, half-brother to North Korean leader Kim Jong Un, when they smeared VX nerve agent on his face in the busy Kuala Lumpur airport; it is widely believed that Kim Jong Un ordered his half-brother's assassination.
- During his multimedia state of the nation address on March 1, 2018, Vladimir Putin unveiled several nuclear weapon systems designed to threaten the United States, and showed a graphic video depicting a nuclear attack on Florida.
- On March 4, 2018, two suspected Russian intelligence agents attempted to assassinate a former Russian military officer and double agent for the UK's intelligence services, along with his daughter, using a Novichok nerve agent in Salisbury, England.
- From 2012 thru 2018, the Syrian military is reported to have conducted dozens, if not hundreds, of chemical attack on its civilian population.
- Following Russia's deployment of an intermediate range missile, the United States announced in February 2019 that it will withdraw from the Intermediate Nuclear Forces Treaty effective August 2019; Russia announced it will also withdraw, and a five-year extension of the New START Treaty beyond its February 2021 expiration date seems to be in doubt.

For more than 25 years, our military has been focused on conventional warfighting and counterinsurgency operations. Furthermore, nearly 95 percent of today's military personnel entered service after September 11, 2001. Consequently, they did not spend years studying how to fight a near-peer adversary and assessing how to prevent a nuclear exchange or massive chemical attack as a possible outcome of the conventional operations they were planning or executing. During that same time, Russia, China and other potential adversaries have modernized their strategic forces, expanded their CBRN capabilities, honed their tactics, and pursued asymmetric means to counter our conventional dominance. They are openly challenging the international order through aggression, coercion, subversion, and deception. Concurrently, regional and global actors seem to have established an acceptance for limited use of chemical weapons and openly threatening nuclear use against the United States.

In considering how to respond to this trend, the United States must appreciate that 21st Century deterrence involves more than just possession of a particular capability, to include nuclear weapons, for two important reasons.

First, with each potential adversary comes a different set of perceptions, interests and dynamics. Our challenges and interests vis-a-vis Russia are not going to be the same as our challenges vis-a-vis China or North Korea or Iran. Deterrence today is far more complex than it was in a bipolar world, and the "one size fits all" containment approach used against the Soviet Union will no longer work. Operations countering one adversary have potential unintended consequences when interpreted by other potential adversaries or our allies. This regional, multi-polar and all-domain environment requires collaboration among combatant commands, the services, allies, and partners to ensure individual efforts do not adversely affect the globally integrated approaches to each problem set.

Second, deterrence is an active sport. The simple act of possessing nuclear weapons or an effective mitigation capability—such as mass decon—is not enough to deter a resolute adversary, and we must guard against falling into that mindset. To be effective, the United States military, and especially the Army, must relearn how to actively deter adversaries armed with nuclear, chemical, and biological weapons by continually demonstrating that the use of nuclear, chemical, or biological weapons will not allow them to achieve the outcome they desire—presumably an easy victory or perhaps even no fight at all. The Army deters CBRN attack by actively demonstrating that the presence of CBRN hazards will not degrade our ability to survive, fight, and win against any adversary in any environment at any time.

This is where you come in. It does not matter if you are military or civilian; part of the Army, Navy, Air Force or Marines; active duty, guard or reserve. You are the ones who will be most influential in deterring and, if necessary, responding to adversary WMD use. We must weave CBRN scenarios into training exercises to increase our readiness to operate in a CBRN environment. We must work through the difficult challenges associated with CBRN environments, such as how to handle radiologically contaminated remains, until we become proficient. Our adversaries must see both our capability to effectively operate in any environment they can create, and our will to do so. In this way, we have the greatest potential to deter adversary use of WMD.

In summary, our potential adversaries are building and operating strategic weapons, not as science experiments, but as direct threats to the United States of America. Make no mistake, the components of our nuclear forces have always been, and will continue to be, the backbone of our nation's deterrent force. But you who have devoted a portion of your lives to our Nation's defense—potentially in the most unimaginable environments—can make the most significant impact. Never forget that your efforts matter. Allies, partners and even the other services are looking to you, the Army nuclear deterrence, CWMD, and CBRN defense experts, for leadership and security in these uncertain and volatile times. They look to you because you can and will make a difference. Do not forget that.

Raising CANE*: The Army Needs to Reintroduce Concepts, Doctrine, and Training for Operating in a Post-nuclear Detonation Environment

Bret Kinman
Contract Support to the Joint Staff J8

* Combined Arms in a Nuclear/Chemical Environment

***Not only must the United States continue to deter major nuclear war, but once again must face the challenge of deterring, and if necessary fighting, a regional conflict with one or more nuclear-armed adversaries.*[1]**

***"The strategic nature of ZAPAD was highlighted by a simulated defence of the Moscow region by S-400 air defence interceptors against a mass cruise missile attack. Dual capable (conventional and nuclear) precision strike capability was also a major element of ZAPAD, including SS-21 SCARAB and SS-26 ISKANDER missile unit activity, with live firing in other regions by ISKANDER units not stationed in the Western Military District. The Ministry of Defence also reported extensive exercise activity by Chemical, Biological, Radiological, and Nuclear (CBRN) defence units, underscoring the Russian Armed Forces' ability to operate in a CBRN-contaminated environment. The exercise activities were conducted in two phases – a first defensive and counter-offensive phase, followed by transition to a second offensive phase."*[2]**

The last 16 years of counter insurgency operations (COIN) in Iraq and Afghanistan have left the Army unprepared for Major Combat Operations that involve the use of tactical nuclear weapons, or the mass use of battlefield chemical agents. The last large-scale exercises that dealt directly with the post-detonation environment were the Combined Arms in a Nuclear/Chemical Environment (CANE) experiments conducted in the late 1980s and early 1990s. The takeaways from the CANE exercises provided a quantifiable and qualitative assessment of tactical unit operations in protective gear. CANE also guided CBRN Defense (CBRND) material development efforts through the 1990s. The next opportunity for CBRND was the initial stages of Operation Iraqi Freedom. The potential use of weapons of mass destruction (WMD) on advancing U.S. and Coalition forces refocused

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attention on CBRND measures, procedures and equipment. Subsequently, the need to find, secure and assess Iraqi WMD programs drove the creation of an ad hoc Task Force with operational and WMD experts. After the WMD survey effort had run its course, the Army focus shifted to counter-insurgency and CBRND was not a significant factor in COIN operations save occasional site survey and WMD materials recovery work. The Army has not conducted a large scale (Battalion or above) level combined arms exercise where the CBRN threat was a baseline operating condition in more than 25 years. However, WMD and CBRN threats have increased and become a part of the nation's defense and military strategies.

One outcome of Operation Iraqi Freedom was the establishment of a new Department of Defense (DoD) mission area-known as Combating WMD–later changed to Countering WMD (CWMD). The DoD strategic approach to CWMD is focused on three lines of effort (LOE): Prevent acquisition, contain and reduce threats, and respond to crises. These LOEs are supported by the continuous cycle of Prepare. In the period after OIF and prior to recent events such as the rise of Russia and China, as well as the progress on North Korean and Iranian programs, CWMD programs and activities focused on site exploitation and WMD program elimination, with additional emphasis placed on interdiction efforts to halt the movement of WMD related materials around the world. In this view, the operating environment was at worst semi-permissible and the focus was on identifying, confirming and eliminating materials from a fixed site or sites in a geographic area. This effort was predicated on acting before such weapons and materials could be utilized against U.S. and Allied forces. However, the continued development of nuclear and other WMD programs by major state actors to include Russia, China, Iran and North Korea has not been deterred by the set of CWMD actions during the past 15 years. Notably, several State actors (mainly Russia and China) have begun to reintroduce the use of tactical nuclear weapons in doctrine and exercises. Planning and executing combat operations in a post-detonation environment will challenge unit staffs and commanders. Understanding of nuclear weapons effects, chemical agent hazards, as well as detection and protective equipment capabilities and limitations and mitigation procedures, are all part of a declined knowledge base for the US Army. Lack of familiarity with the post-detonation operational environment and the associated tactical and operational implications hint that the Army must take steps to re-learn this potential facet of modern war.

U.S. forces will ensure their ability to integrate nuclear and non-nuclear military planning and operations. Combatant Commands and Service components will be organized and resourced for this mission, and will plan, train, and exercise to integrate U.S. nuclear and non-nuclear forces and operate in the face of adversary nuclear threats and attacks.
-2018 Nuclear Posture Review

How did we get here?

The CANE experiments were conducted at the end of the Cold War, but subsequent shifting priorities for the Army resulted in a rapid loss of institutional knowledge for dealing with this type of threat. This series of experiments were done to gauge the impacts of Mission Oriented Protective Posture (MOPP) level 4 on platoon/company and battalion level combined arms operations.[3] Clearly, the addition of a protective suit, boots, and gloves, as well as a protective mask would have impacts on the ability of any

Soldier to operate compared to operating with only normal combat equipment. The CANE experiments quantified and qualified those impacts. The last experiment was held in May of 1992. With the end of the Cold War and a reorientation of the U.S. defense posture, these experiments were completed and informed the effort to improve protective gear, even as the Army shifted its focus to stability operations in the Balkans and then after 9/11 to the Mid-East and Southwest Asia. While the initial phases of Operation Iraqi Freedom considered a battlefield use of chemical agents, once the operational defeat of the Iraqi military had been achieved this concern shifted to the WMD program elimination effort. The effort to identify, search, and ultimately eliminate the Iraqi WMD program defined the tenor and scope of U.S. CWMD efforts for the next decade.

The focus of CWMD operations became site centric and led to an emphasis in terms of training, equipping and doctrine of US CBRN organizations and the development of tactical and operational concepts to support that emphasis. This construct was centered primarily on the Korean peninsula, incorporating lessons from Iraq. While there was a broad understanding of the North Korean WMD capability, a true understanding of the program facilities, locations, and related pathways was less well understood. There was also a belief that chemical agents could be used by the North via missile or rocket strike on theater ports and airfields to delay the arrival of U.S. and Allied forces and their needed logistics. In certain situations, nuclear weapons were both a theater and regional concern as they had the potential to deny or limit access of the U.S. and Allies to the peninsula. Mapping suspected WMD program facilities and developing a concept of operations to confirm and then exploit these locations became a focus of the CBRN community. In addition, the integration of the Counter Improvised Explosive Device (CIED) operations into parts of the CBRN mission space further took focus from the more traditional combined arms operational concerns of CBRN Defense.

Concurrently, as part of a post-9/11 effort to "harden the homeland," DoD began to conduct a series of disaster response exercises and, in some cases, to conduct actual response operations (e.g. Hurricane Katrina). These exercises were intended to not only refine the overall government response to a "major" event in the U.S. but, more specifically, how the DoD would support Civil Authorities from local to national levels. Those who have been around awhile would understand this as Civil Defense. Most notably, the US Northern Command (USNORTHCOM) Vibrant Response exercise series began in 2009. This exercise scenario utilized a 10-kiloton improvised nuclear device detonation in a major US city (based on the #1 National Planning Scenario)[4] and served to better integrate DoD Defense Support to Civil Authorities (DSCA) response capabilities with that of the Federal Emergency Management Agency and the relatively new Department of Homeland Security. This annual exercise serves as the only large scale CBRN (R/N in this specific case) exercise conducted by the DoD. However, as noted, Vibrant Response is predominantly a DSCA exercise utilizing a CBRN event as the scenario baseline. Yet, Vibrant Response does provide insight into the state of preparedness for units that might operate in a post-detonation nuclear environment.

With the more recent rise of Russia and China, both nations with offensive WMD programs, the perceived possibility of conflict, while limited, is still greater than believed even five years ago. The list of U.S. near-peer competitors are nations that all have nuclear weapons or nuclear weapons programs and have extant chemical weapons stockpiles. As the U.S. begins to look at the possibility of conflict, even on a small scale, the possibility of nuclear or chemical weapons use can no longer be discounted.

Lessons from Vibrant Response

Despite its inherently DSCA focus, Vibrant Response offers some insights into what Army leaders, staff, and units may face when dealing with a post-detonation environment (either as part of combat operations or as part of a response effort). Army units compose the preponderance of the Defense CBRN Response Force (DCRF) in support of USNORTHCOM. The DCRF operates four main Task Forces: Operations, Aviation, Medical, and Logistics. The Task Forces are composed of task organized capabilities from across the Army to include: Engineering, CBRN, Military Police and Communications, as well as Aviation, Medical and Logistics capabilities. All the units that have operated as part of the DCRF gained valuable experience during Vibrant Response, which supplements their wartime-related missions that could involve CBRN Hazards, to include a post-detonation environment. Since the exercise offers the only opportunity for portions of the Army to exercise the CBRN problem set on a large scale, many exercise observations are indicative of related challenges of a large scale CBRN problem in a non-DSCA exercise environment. The following observations highlight points relevant to operational units and articulate associated challenges for radiological and nuclear training and exercises:

<u>Overall lack of knowledge for operating in a post-nuclear detonation environment</u>

The implications of de-emphasis on CBRN defense training over the past 16 years is recurring and evident. This observation has been noted during multiple Vibrant Response exercises, although DCRF units have improved their overall radiological and nuclear acumen. Yet, this knowledge remains fleeting as units experience turnover and other distractions outside the Vibrant Response training window. During Vibrant Response, unit leaders and staff face a steep learning curve to recall CBRN defense tactics, techniques and procedures (TTP) and the application of those TTPs for unit planning and operations. There are two main points of emphasis: Understanding and applying the concept of "As Low As Reasonably Achievable" (ALARA) and understanding radiation hazards from weapon fallout (to include decontamination). First, limited understanding and application of ALARA imperatives: time, distance ,and shielding from radiation sources in relation to overall mission execution and accomplishment. This is a more difficult challenge in the post-detonation environment. A post-detonation environment with fallout will produce a wide field exposure hazard as opposed to a fixed facility with radioactive materials, which generally represents a point source hazard. In both cases, ALARA principles still apply in terms of mission planning. The need to manage exposure of service members operating in contaminated areas, while conducting lifesaving operations, continues to require additional training and education for unit leaders and staff. Unit leaders and staff need to understand the ALARA principles in relation to mission and operational planning. However, ALARA does not mean no exposure and unit leaders and staff must be able to manage the difference in operations.

Second, and more specific to the observation above, there is limited understanding of overall hazards from radiation, and specifically fallout. Weapon radiation effects are significant at the instant of detonation, thereafter the effects of radioactive fallout are the predominant radiation hazard. However, fallout is primarily hazardous if ingested in to the body. Still, fallout material collects in and on vehicles and operational equipment and can be a constant hazard. Personal and personnel decontamination for fallout is straightforward. Removal of contaminant material from the individual is accomplished through a combination of a dry process i.e. brushing material off and a more thorough wet decontamination i.e. a shower. The main difference from a DSCA environment to that of ombat operations is the type of personal protective equipment utilized. Given the permissive nature of DSCA operations, and Occupational Safety and Health Administration guidelines, units utilize a one-use protective suit, which allows freedom of movement, reduces environmental fatigue, and reduces decontamination time. This will not necessarily work for units in combat operations where the more robust Joint Service Lightweight Integrated Suit Technology ensemble is utilized. Current approaches to personnel and equipment decontamination remain and need to be practiced for a post-detonation environment. Multiple lessons from the Fukushima disaster response, Operation Tomodachii, provided insight into radioactive contamination control issues. While personnel decontamination was straight forward, the larger learning point was the level of radioactive contamination found on and in vehicles and aircraft. This decontamination effort was more intensive and took much longer than originally expected. Granted the decontamination effort during operation Tomodachii was not under combat conditions, but radioactive dust i.e. fallout will find its way into vehicles and spaces and crevices of vehicles and will complicate operational execution

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<u>Limited ability to accurately replicate the post-detonation environment</u>

The variety of plume modeling software available to users, or upon request, provides a realistic depiction of the primary nuclear weapons effects and aligns with the Department of Energy construct for effects.[5] This construct uses a 5-Zone laydown: Three Damage Zones (Severe,

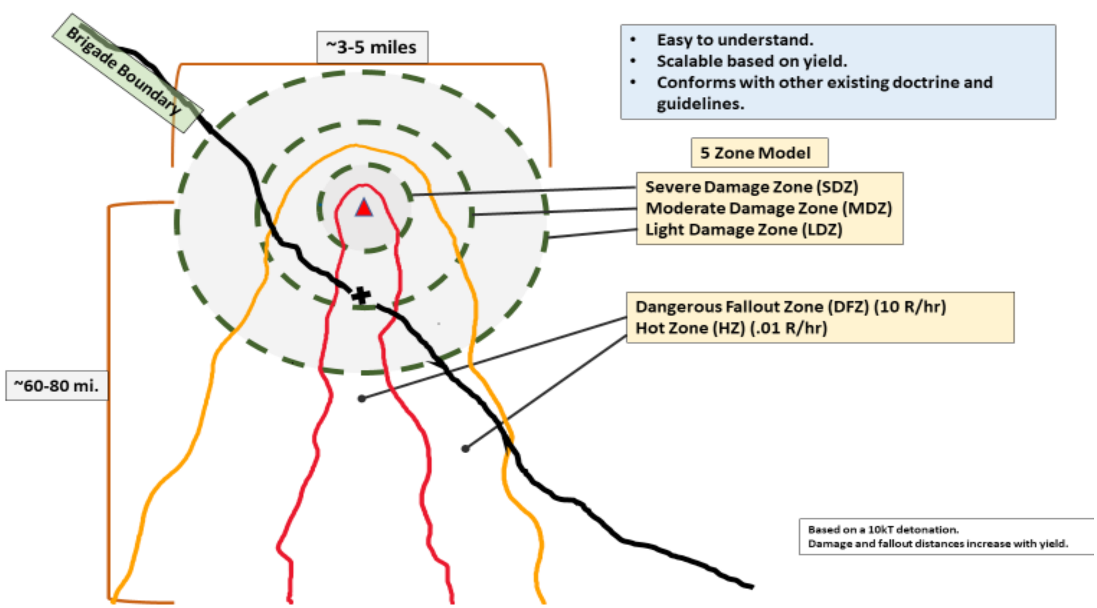

Figure 1. Concept sketch of the 5-Zone model overlaid on simple maneuver graphic.[6]

Moderate, Light) and Two Contamination Zones (Dangerous Fallout- bounded by the 10 R/hr line and Hot Zone- bounded by the .01 R/hr line). The 5-Zone model/construct should be adopted by DoD for both DSCA doctrine and for use in tactical and operational doctrine. The model is easy to understand and provides a very translatable common reference to both physical damage as well as radiation hazards.

Although Electromagnetic Pulse (EMP) effects are more challenging to model, existing capability provides enough fidelity for exercise planning and execution purposes. This level of accuracy is sufficient for the purposes of a simulation where the preponderance of the exercise is done virtually. However, once the exercise departs the virtual realm and moves to the field training portion, the ability to accurately and realistically replicate fallout with a replicant material (ash, soot etc.) and create a post-detonation environment to include a wide-field radiation reading to detection instruments is very challenging. Both issues will require additional analysis to fully integrate into a large-scale exercise environment given the associated environmental compliance issues and complex handling restrictions.

<u>Translation of exercise observations from DSCA to Major Combat Operations</u>

A final observation is the translation of exercise planning and execution lessons from a DSCA environment, which is more benign and is a relatively unconstrained environment in terms of threat and support. Clearly, an overseas major combat operation would take place in a higher overall threat environment and operations would take place with more constraint in terms of support and logistics. Nevertheless, as the DoD begins to look at potential adversaries and operational environments, the inclusion of nuclear weapons use, in or near U.S. operating units and forces, is an emergent concern. Vibrant Response and its companion field training exercise Guardian Response provide the only current large-scale exercise environment with which to improve understanding of the post-detonation operating hazards and associated planning and mitigation approaches.

There is clearly a basis to incorporate nuclear and chemical weapons' effects into exercises. While the Army may consider running a modernized series of tactical exercises like CANE, the larger point is to incorporate these effects into existing and future exercises. Providing the exercise adversary nuclear and chemical weapons and allowing for their use in exercise scenarios is a major aspect of educating organizations and their leaders about the tactical and operational impact. What is not necessarily needed is a set of stand-alone exercises that only center on the use of nuclear and chemical weapons. While these types of activities have their place to test certain tactics, techniques, and procedures and plans or demonstrate technology, their benefit is more focused. Reincorporating nuclear and chemical weapons effects to existing Army training and exercises is the best way to retrain Soldiers and leaders on these potential operational environmental impacts.

Where to go?

The U.S. Army and DoD should also (re) energize planning, wargaming, and analysis for nuclear operations, and wargames should continue post-nuclear explosion. As the Russian Armed Forces expect to conduct offensive and defensive operations after a nuclear strike, the U.S. Army should also reinvigorate training within a nuclear

environment to ensure leaders and Soldiers are confident operating in contaminated areas.[7]

There are any number of exercise scenarios that could incorporate use of a nuclear weapon and its associated effects. As the Army begins to reorient its training and exercise programs to Major Combat Operations involving some aspects of combined arms fire and maneuver, as well as stability operations, incorporation of nuclear and chemical weapons use is pertinent and relevant. While other forms of WMD (i.e. biological) weapons may still be utilized by potential adversaries, none can create the tactical, operational (as well as strategic) disruptions that nuclear weapons can. In observing chemical weapons use in Syria, the use and effect has been very localized and non-persistent, their tactical impact would be more significant than at the operational or strategic level. Alternatively, nuclear weapons use on or near a U.S. force concentration would have immediate impacts on the tempo and scale of operations and the effects would be persistent over weeks. A nuclear exchange by two nations may involve a post-event response, where U.S. forces comprise the sole or some part of an international response. In both cases, U.S. forces will need to be trained and ready to deal with the post-detonation or post-use environment.

As noted above, the challenge of replicating a realistic post-detonation environment, or post-chemical agent use environment seems daunting. Yet, the need to reintroduce these hazards and their related operating environments into training is evident. While the CANE exercises were designed to identify certain specific operational impacts, the current challenge is broader. Re-educating the force on weapons effects, operational impacts and TTPs will require command emphasis, leader support, and an executable program. The ability of virtual training to assist in training units and staffs to understand the effects and operational impacts is much improved. The combination of virtual training coupled–eventually–with realistic field training will be the most effective path to improving the preparedness of the force. A few key ideas the Army (and the Joint Community) should incorporate into exercises are below:

Training & Exercise Goals:

1. Integrate nuclear and chemical effects into existing major exercises and field training [platoon to corps].
2. Develop and integrate early warning, deterrence, and weapons use as both tasks and conditions.
3. Develop and fight adversary doctrine for nuclear and chemical use.
4. Exercise impact of weapons on both fielded forces and infrastructure.
5. Use weapons effects to impact Maneuver, Protection, Mission Command, and Logistic
6. Improve Soldier and Leader understanding of nuclear and chemical weapons effects.
7. Develop realistic replicants for nuclear fallout and chemical agents.

There is a final thought on the need to refresh Army doctrine and associated training products and services. As noted above, there is a need for incorporation of nuclear effects into training and improving field training replicants but beyond that, the Army needs to refine and refresh its doctrine. The Army needs to shift primary focus of CBRN forces away from fixed WMD site exploitation and back towards tactical, operational, and strategic CBRND operations. A large part of that shift requires updated and revised doctrine. As a start, the Army has begun work on redeveloping and publishing a Nuclear Operations Field Manual (formerly known as FM 100-30) and continues work on CBRN tactical and operational level doctrine to reflect the change in operating environments from COIN back to large scale combat operations. Although much of this doctrine already exists, albeit dated from the end of the Cold War, updating it is easier than staring at a null point. Incorporating revisions to TTPs, equipment, and formations, while challenging, will still be a lighter lift than creating from it scratch. Similarly, the Army should update and re-publish the various "whiz wheel" type effects calculators, so that units have a manual backup for assessing weapons effects in a tactical environment. Finally, the Army should prioritize training programs and academics that train and educate Soldiers on nuclear weapons effects. This can be done in an exportable way, where the training is conducted with units at home station and potentially avoids the inevitable tradeoff in professional school curricula time allotments.

Conclusion

As the threat environment changes from counterinsurgency to the re-emergence of State-on-State conflict, the possibility of nuclear weapons use in or near an operating area is also shifting and possibly increasing. The Army will need to begin re-learning that which it has largely forgotten–the effects and impacts of a post-detonation nuclear (or chemical agent) environment. While the comparative impacts of even a low yield nuclear weapon and that of moderate scale chemical agent use are different, the operational impacts for Army tactical and operational units would be significant. Keeping in mind the axiom "it is better to stay up than catch up", the re-introduction of nuclear and chemical weapons effects to Army (and Joint) training is needed. There is a need for both an academic approach to training Soldiers on the effects, detection systems, mitigation, and related matters and to incorporate the effects of a post-nuclear or chemical operating environment into exercises. The CANE experiments were the last full-fledged effort at understanding how well Army units could perform combat operations in a nuclear and chemical environment. There is ample reason to resurrect that work, apply the improved technology of 2018 and re-acquaint the Army with this threat.

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An Appeal for a Nuclear Perspective in Army Education

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United States Army War College

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, Following last year's indications that the United States would withdraw from the Intermediate Nuclear Forces (INF) Treaty, Russian President Vladimir Putin warned that such a move would lower the threshold for nuclear war between the two nations. The 1987 treaty eliminated all ground-based, nuclear-capable weapon systems with ranges of 500 to 5,500 km from each nation's inventory. Despite this warning and citing Russian treaty violations, the United States officially suspended its

Figure 1. installation of ARDIMS (Aerial Radiation Detection Identification and Measurement System) on a UH- 60. ARDIMS consists of gamma and neutron detecting pods. During the National Technical Nuclear Forensics (NTNF) mission, it is used to map the fall-out field from a nuclear detonation and plan interagency missions for sample collection.

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INF involvement in February 2019, pending full withdrawal later in August. Shortly after, Moscow threatened nuclear strikes on targets within the continental United States, signaling the danger that could arise from the erosion of post-Cold War nuclear arms control.

This sobering 21st century return to a 20th century relationship between the United States and Russia requires military planners to consider the expanding role nuclear weapons now have. Recent Russian development of low yield, sub-kiloton nuclear weapons such as tactical Close Range Ballistic Missiles and dual-use cruise missiles should give Army planners in particular considerable pause. Within this context, they need to have some knowledge of U.S. nuclear capabilities and planning processes, should they become necessary in a future conflict.

One could assume that Navy and Air Force planners have the market cornered on nuclear matters. These two services operate all three legs of the U.S. nuclear triad — intercontinental ballistic missiles, submarine-launched ballistic missiles, and heavy bombers. Yet in almost all imagined cases, these systems would deliver effects on the land, potentially ahead of or in some proximity to conventional ground maneuver formations. Further, the Army, through the US Army Nuclear and Countering Weapons of Mass Destruction Agency, has a requirement to provide planning capability for the joint employment of nuclear weapons. Army leaders should not consider themselves a service of bystanders in nuclear operations.

Therefore, mid-grade Army officers—the ranks who fill planning assignments on joint and land component commands—must be armed with an understanding of nuclear weapons in deterrence and employment. A nuclear appreciation may be critical to integrate effects, provide options in planning, and offer perspective for senior leader decisions. Unfortunately, there is virtually no curriculum and a tragic lack of emphasis on nuclear matters within the current Army professional military education pipeline to gain these skills.

Nuclear education used to be a core component of Army professional military education and required reading along with contemporary doctrine. Air Land Battle doctrine, the grandfather to current Unified Land Operations doctrine, anticipated nuclear use in concert with conventional operations. Yet for understandable reasons, the priority has atrophied since the end of the Cold War.

Nuclear studies at the Command and General Staff School peaked at 600 hours of core curriculum by 1960. However, nuclear treaties and the overwhelming, non-nuclear, conventional success during the Persian Gulf War drove a decline in demand for nuclear education at the staff college. Further, the 1991–92 Presidential Nuclear Initiatives mandated the withdrawal and elimination all non-strategic nuclear weapons from Europe. This forced the end of most nuclear training and education at the U.S. Field Artillery School—then the proponent for Army nuclear capabilities such as the Pershing II missile and W82 nuclear artillery shell. For nearly the past 20 years, operational requirements have driven the study of low-intensity conflict and Army officers have rightly become professionals in it. However, this has come at the expense of high-intensity warfare, to include nuclear planning, doctrine, and operations a generation of officers understood, lived, and breathed not too long ago.

Outside the Functional Area 52 Nuclear and Counterproliferation career path, the only options for nuclear education for an Army major or lieutenant colonel may be at the Defense Nuclear Weapons School. Headquartered at Kirtland Air Force Base and subordinate to the Defense Threat Reduction Agency, the school offers or hosts a broad menu of courses on nuclear issues. In particular, the U.S. Army Nuclear and Countering Weapons of Mass Destruction Agency runs the Theater Nuclear Operations Course. While an outstanding, voluntary course, much of the Theater Nuclear Operations Course material is not— but should be—part of a core professional military education curriculum. Little service-wide nuclear education implies there is no common appreciation for nuclear deterrence, triad capabilities, nuclear doctrines of potential adversaries, or options of integrating nuclear with conventional operations. Army planners who are unable to speak this nuclear language may struggle to provide nuclear options in planning. They may dismiss this kind of recommendation altogether assuming it is too unlikely or disproportional, an artifact from bygone days of warmaking and deterrence messaging among great powers.

Yet here we are, faced with a strategic environment involving renewed great power competition among nuclear-capable adversaries preparing its force for a tactical nuclear fight. In this light, mid-grade Army officer education—Captains Career Courses, Intermediate Level Education, and potentially the Advanced Military Studies Program—should include nuclear considerations as a part of their lesson plans. This will provide officers who serve on planning staffs at division, corps, service component, and joint force commands with baseline insights into nuclear deterrence and operational integration.

To produce officers capable of meeting this emerging requirement, the following topics may be useful. They come from the work the Basic Strategic Art Program, the qualification course for Functional Area 59 Army Strategists, has done to ensure its graduates have experience in deterrence and nuclear planning. One does not suggest other Army schools should adopt everything here, but consider it a menu of practical options, scalable to any level, all in order to get students thinking nuclear.

Nuclear Deterrence Theory

Theory is foundational to explaining the phenomenon of war and useful in anticipating future trends and behaviors. Professional military education should include some theoretical discussion to frame out nuclear history and identify current and future trends. Readings may include excerpts from Thomas Schelling's Arms and Influence or Bernard Brodie's Strategy in the Missile Age, both foundational works on nuclear deterrence. Beatrice Heuser's The Evolution of Strategy develops several enduring strategic themes within a nuclear context such as deterrence by denial or punishment, the Clausewitizian "maximum exertion of strength," war termination, and moral issues. Lawrence Freedman's concise book (a modest 140 pages, considering the broad survey it provides), Deterrence offers a solid appreciation for the theory as one facet of coercive strategy. Freedman provides a chapter in Peter Paret's Makers of Modern Strategy that covers the evolution of U.S. deterrence policy, weapons development, and challenges of extended deterrence within NATO. Countless works could make the list, but these may be the most available, accessible, and broad enough to provide a solid foundation for the Army professional. More importantly, they highlight deterrence as a coercive strategy and the role nuclear capability plays as a major (if not ultimate) deterrent among great power adversaries.

Nuclear Deterrence in Practice

Assuming nuclear non-use is a good thing, then an historical study of how the United States and others have deterred conflict from escalating to the nuclear level may be useful. Deterrence history should focus on how the shadow of nuclear weapons kept a limited conventional conflict from growing into something more serious.

A prime example is non-use during the Korean War, a case where U.S. senior leadership considered nuclear weapons, but constrained operations to conventional means. Nina Tannenwald, Director of the International Relations Program at Brown University, describes the evolution of a nuclear taboo that has precluded the nuclear option from the end of World War II through the various setbacks in Korea. Moral revulsion, disproportionality, a lowered threshold for future use, and even fears of racism precluded nuclear use in Korea. However, there is a practical strategic lesson in the narrative.

Although nuclear use on Chinese targets in Manchuria would have provided an operational effect in stymieing third-party intervention, non-use allowed the war to stay limited—even if bloody and inconclusive—geographically to the Korean peninsula. One of Truman's fears was that a nuclear attack would induce the Chinese to invade and retake Taiwan, expanding the theater of war in the Pacific. The United States did employ nuclear capability elsewhere, however, during the same period to deter other would-be adversaries. Truman ordered nuclear-capable B-29 strategic bombers to Great Britain to ward off any Soviet impression of military weakness they may have gleaned from Korea and opportunistic moves in Europe. From this or many other case studies, students could appreciate the vertically escalating potential of nuclear weapons and their ability to neutralize horizontal escalation across regions and threats.

Korea, 1950 to 1953, provides a good illustration on nuclear theory in practice for the Army planner, but other examples exists: the Berlin Crisis of 1961, the Cuban Missile Crisis, Able Archer 83, or more contemporary situations such as India-Pakistan tensions or North Korea 2017–2018. The intent is for a post-Cold War generation of practitioners to explore nuclear deterrence from recent history through today. They may realize that the mere existence of nuclear weapons, like the notion of a fleet-in-being, provides a continuous means to deter and influence adversaries.

The 2018 Nuclear Posture Review and Nuclear Capabilities

The Nuclear Posture Review is the most strategic, current, and publicly available document the Defense Department has that describes U.S. nuclear policy and arsenal. It should fall alongside discussion of other defense and national strategy capstone documents. The review may be the ideal point to discuss characteristics of the nuclear triad—potentially an unfamiliar notion to younger Army planners—to include benefits and limitations of each leg.

Since the 2018 Nuclear Posture Review, nuclear modernization and development has returned to a top Defense priority. Students should explore the history of the Army's role in the nuclear enterprise as it sought a niche in the non-strategic ("tactical") arm of nuclear capability. Discussion on the Pentomic Division or nuclear artillery do not need to fall within the museum of Cold War oddities and relics. They can serve as perfect examples of organizational and materiel force management decisions, made by thoughtful people trying to solve operational and strategic problems. They can help explain the interplay among threats, doctrine, budget, and the force. Anticipation of a nuclear battlefield helped shaped the development of Active Defense and Air Land Battle doctrine and the "Big Five" weapon systems. Students of war ought to consider how the potential for a nuclear battlefield tomorrow should shape force management, doctrine, and investment decisions today.

Adversary Doctrine and Capabilities

Lessons that have a regional focus must draw the student's attention to the nuclear postures, policies, and known doctrines of potential adversaries. At a more practical level, planning exercises should include considerations for operating on a nuclear battlefield and appreciation for the ranges and yields adversaries could bring to bear in a conflict. Useful, unclassified data for these purposes is widely available. The intent here is for Army officers, as students of the profession, to be as familiar with adversary nuclear capabilities and doctrine as they are with adversary conventional capabilities and doctrine.

Nuclear-Conventional Integration

Future Army planners should become familiar with how to integrate nuclear and conventional operations and how to provide a nuclear option to a geographic combatant commander. These leaders may have a critical role in ensuring nuclear effects complement a conventional fight. Using the Integrated Weapons of Mass Destruction Toolset—an unclassified "For Official Use Only," web-based system that requires minimal familiarization to use—students could model nuclear effects in order to offer it as an option during exercise course of action development. Modeled fallout projections would force planners to consider risk to the friendly formations and propose alternative routes to steer clear of radiation. They could become familiar with nuclear strike warning messages to provide safe operating distances for ground forces. In all cases, the tools and considerations for nuclear-conventional integration are practical and useful for Army planners.

Army officers need a more pragmatic appreciation of nuclear weapons to include how they may be a part of their operational or strategic planning in future assignments. Recoding some planning assignments to require the Nuclear Targeting Analyst additional skill identifier may incentivize commands to send more officers through the Theater Nuclear Operations Course in order to achieve it. However, given the grave challenges of likely future conflicts, the Army must inculcate a service-wide nuclear perspective across the force through professional military education. The above is a recommendation for Army course authors and instructors to consider as a menu of perspectives to include in their curriculum. It is also a recommendation as a start for self-study and development, just as it has been for this author. More importantly, developing a new generation of Army officers, educated in nuclear planning and proficient in operating on a nuclear battlefield, has a deterrent value all its own. Considering the current adversarial conditions with Russia, planners need to stop considering nuclear weapons as something different and unspoken, but as a likely tool should the call be made.

Three Dimensional, Real Time, Radiation Mapping with Scene Data Fusion

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The Localization and Mapping Platform (LAMP) is a real-time, three-dimensional (3-D) radiation mapping system developed by the Applied Nuclear Physics program at Lawrence Berkeley National Laboratory (LBNL). LAMP performs Scene Data Fusion (SDF) by integrating gamma-ray detector

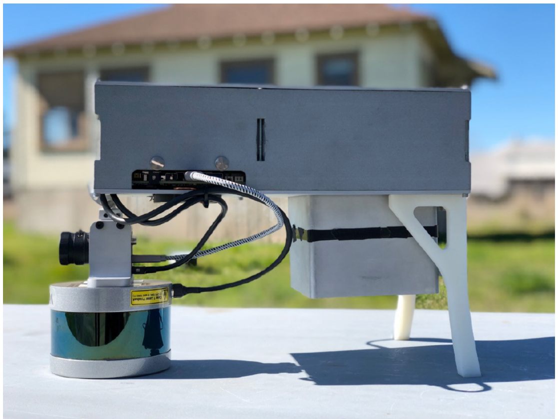

Figure 1. The Localization and Mapping Platform (LAMP) with a custom multi-planar CdZnTe (CZT) crystal array, MiniPRISM, which enables reconstructions that leverage Compton as well as coded-aperture imaging.

systems with a suite of contextual sensors (LiDAR, IMU, visual camera) to build 3-D scenes with the embedded gamma-ray emission distribution. SDF is achieved on LAMP through voxelization of the 3-D contextual scene and fusion of the nuclear instrument data via maximum-likelihood expectation-maximization (ML-EM). While two-dimensional (2-D) imaging systems have proven useful in specialized applications, 3-D SDF mapping is the way of the future for mobile radiation detection systems. It enables mobile acquisitions that improve overall radiological search and mapping performance while maximizing the operator's situational awareness by providing the radiation distribution information fused with a detailed 3-D map of the search area. This new method of deploying radiation detection systems enables greater deployment flexibility and mapping of large areas. With the continued improvement in computational processing power, SDF is executed on-board LAMP in real-time with a streamlined data product broadcast to the operator on a wireless data link. The operator can see the map update on his display as the sensor moves through the environment, while the scaled radiation localization estimate is continuously updated with new data. The complete data set from the search is stored on-board the system and is available for post-mission analysis by the operator. LAMP provides sub-meter localization of both point and distributed radiation

Figure 2. LAMP is easily deployed on a variety of platforms. With a weight of approximately 10 lbs, the system can be mounted on the optimal platform for the mission.

sources and provides a 3-D scene map with < 10 cm spatial resolution. LAMP is platform agnostic and has demonstrated its nuclear reconnaissance capability on a small Unmanned Aerial System (UAS) DJI Matrice 600, on a Unmanned Ground Vehicle (UGV) system deployed on a PackBot 510, and in hand-held configurations.

LAMP's capabilities are fully utilized by the warfighter when deployed on the UAS for large area reconnaissance. The DJI Matrice 600 provides a robust aerial platform with a 5 km range and the ability to broadcast video and mapping data products back to the control station. This system maximizes standoff for the operator while providing the greatest amount of situational awareness of the terrain and any radiological activity–be that contamination or other forms. The hexacopter design allows the operator to get the system significantly closer to the target area, interrogate objects or buildings for longer than a fixed wing UAS, and maximizes operator control over the UAS. Figure 3 shows the results of a contamination mapping activity where two controlled blasts distributed several curies of radioactive material with a short-half life. This mapping covered a ~10,000 m2 area, was performed in less than 10 min, and correctly localized the two blast sites even though they were in close proximity to each other. The same mapping using traditional 2-D Global Positioning System (GPS) heat mapping techniques was

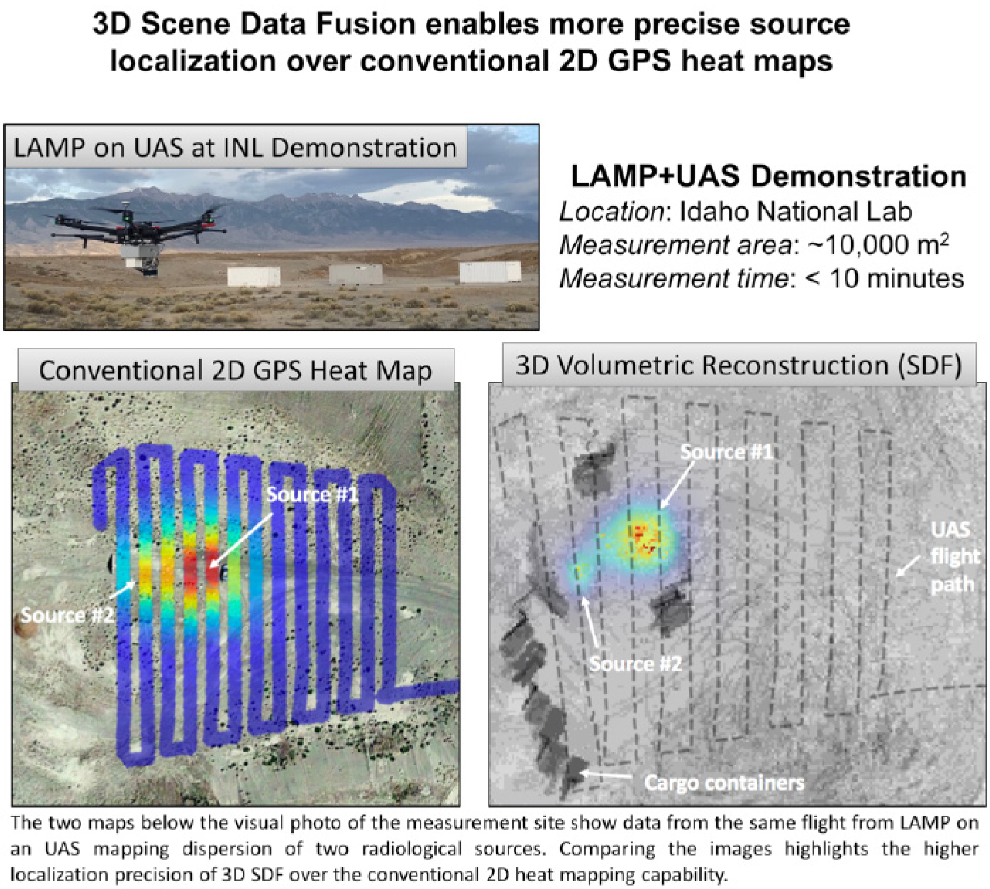

Figure 3. Results from a mapping activity at Idaho National Lab with CsI(Tl) LAMP mounted on the DJI Matrice 600. LBNL's 3D SDF mapping approach (right) provides more precise localization and distinction between the data sources compared to the conventional 2D GPS heat map approach (left).

unable to resolve the two distinct contamination areas. The small UAS configuration exhibits further improved performance in urban areas, where the abundance of contextual features that are not present in an open field further enhances the value of the SDF process. Figure 4 shows a post-processed image from an aerial reconnaissance of a Military Operations in Urban Terrain site at Camp Roberts, CA. This simulated multi-story urban area was fully mapped in < 15 min, with the source correctly localized to the near corner room on the top floor of the indicated building (the radiation reconstruction was limited in post processing to just the building of interest, although the LiDAR sensor has a 100m range and mapped several of the neighboring buildings during the flight around the target building). Once the building of interest was identified through the UAS reconnaissance, LAMP was hand-carried into the building and detailed 3-D maps indicated the precise location of the source on the top story, as indicated in the initial UAS-based survey. These combined data products provided the operator with excellent situational awareness and planning tools that can also be GPS correlated and are being integrated with TactiAK. Additional applications for UAS radiation mapping are large nuclear facilities, nuclear storage sites, large contamination areas (post-detonation or incident/accident), battlefield damage assessment, and

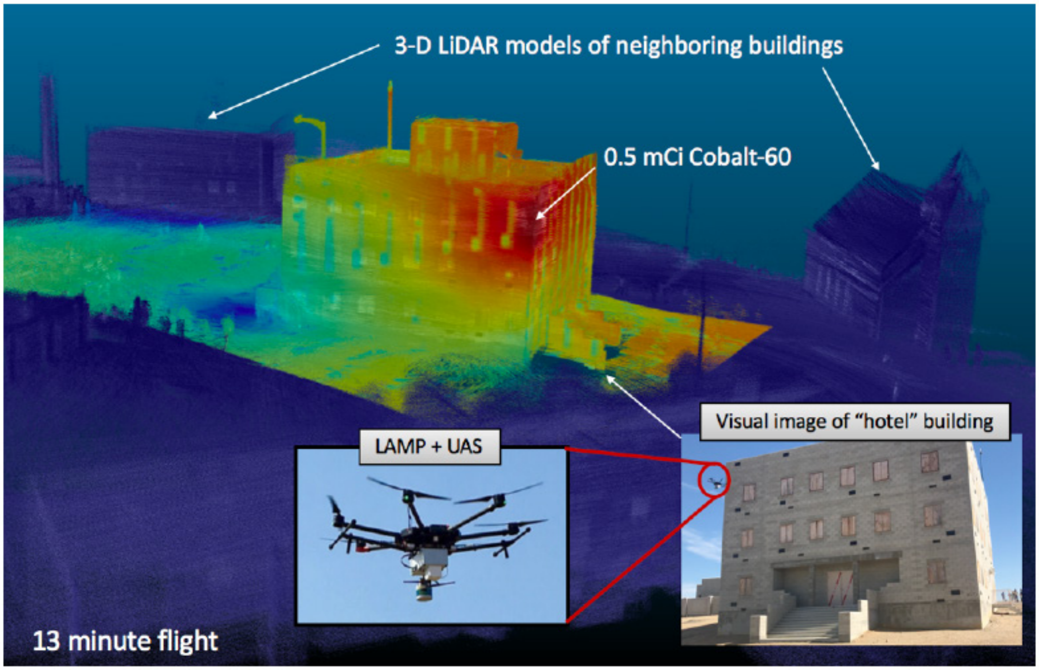

Figure 4. Post processing image of an urban reconnaissance. LAMP correctly localizes the 0.5 mCi Co-60 source on the top level of the multi-story building. The reconstruction was limited in post processing to the area around the building.

contamination avoidance reconnaissance. The UAS is able to map and locate radioactive sources faster than operators with hand held systems and reduces radiological exposure and other hazards to the operator/warfighter. The UAS is also able to map in terrain that is inaccessible or too hazardous for human operators.

The UGV system provides access to enclosed spaces where the deployment of the UAS is not possible and where the deployment of an operator into the environment is not desired. When tested in a subterranean tunnel system, LAMP quickly and effectively mapped the entirety of the tunnel system while accurately localizing radioactive sources. The detailed 3-D point cloud map provides enhanced situational awareness of complex terrain and is unaffected by limited visibility environments (e.g. fog, low/no light). Since the 3-D map provides < 10 cm resolution and can operate in limited or no visibility situations, it is ideal for capturing complex details of urban or subterranean areas easily missed by human operators.

The hand-held configuration of LAMP provides the operator with maximum control of the system allowing for a more customized search. With the hand-held system, users are able to quickly visualize radioactive activity in their area of search. This capability is a powerful tool for decontamination operations allowing for precise localization of activity on equipment or vehicles. LAMP provides the operator with the 3-D model enable the operator to decide where to focus decontamination efforts and to subsequently assess their effectiveness.

LAMP has also been demonstrated to be sensor agnostic and flexible. It has already been fielded with several different nuclear detection systems, which may be selected based upon mission requirements. The core nuclear detection system is an array of four CsI(Tl) detectors used to perform proximity reconstructions to determine the gamma-ray emission rates. LAMP has been integrated and demonstrated with LBNL laboratory prototype detectors, such as the Portable Radiation Imaging Sensing and Mapping (PRISM) and MiniPRISM (Figure 1) CdZnTe (CZT) systems, which enables reconstructions that leverage Compton as well as coded-aperture imaging; and LAMP has been integrated and demonstrated with commercial detector systems, including LaBr and CLLBC scintillators, the latter enables sensitivity to both gamma-ray and neutron emission.

Acknowledgments

This material is based upon work supported by the Defense Threat Reduction Agency under HDTRA 10027-21370, -23334, and -25522. This support does not constitute an express or implied endorsement on the part of the United States Government.

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Gas Centrifuge Flow and Transport Modeling for Breakout Timeline Estimation

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Introduction

In the decades following the Second World War, the gas centrifuge emerged as one of the most efficient methods to enrich uranium. In addition to defense applications, commercial power demand created a large market for enriched uranium, and numerous corporations constructed plants to enrich uranium to serve as fuel for reactors. Abdul Qadeer Khan, a nuclear scientist and metallurgical engineer, infamously stole proprietary and sensitive centrifuge and cascade design information from his Dutch employer, Physical Dynamics Research Laboratory (FDO), a subsidiary of the enrichment conglomerate URENCO, before returning to his native Pakistan to lead their weapons program. In the years since his return to Pakistan, evidence of continued proliferation of this critical information to countries with nuclear ambitions continues to mount.

The current geopolitical landscape includes several small nuclear-power-equipped states with declared or suspected nuclear weapon ambitions. The International Atomic Energy Agency (IAEA) is responsible for monitoring these emerging capabilities and preventing the spread of weapons while encouraging the peaceful proliferation of energy technology. The toolkit for limiting and monitoring the usage of peaceful or dual-use technologies is relatively limited and often requires the collaboration of the state under scrutiny.[1] While actual physical monitoring of enrichment capability is the responsibility of the IAEA, the international community at large must make every possible effort to police each other. This includes developing computational tools to model and predict the enrichment capability of those emerging states to ensure the IAEA and the United Nations (UN) have ample time to react in the event that the state should ``break out'' of their IAEA sponsored agreement framework and make an effort to acquire a nuclear weapon. This paper introduces a few new tools for centrifuge and cascade performance estimation.

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Background

Formed by the US Atomic Energy Commission (AEC) in the 1960s with the goal of obtaining a better understanding of the flow field in gas centrifuges, a research team of notable scholars led by Dr. Lars Onsager of Yale University developed a technique to simplify the countercurrent flow's governing hydrodynamic equations. Defining a master potential for the flow, the Onsager group reduced the system of equations to a single partial differential equation of sixth order in the radial variable and second order in the axial variable, henceforth referred to as the Onsager model.[2] Wood and Morton provided a comprehensive derivation of Onsager's previously unpublished equation, including the "pancake approximation," so-named because the strong rotation forces all of the gas to the rotor wall in, effectively, a pancake. They included in their analysis the effects of sources and sinks of mass, momentum, and energy and obtained a solution for the homogeneous equation using the method of eigenfunction expansion.[2] The basic components and construction of a countercurrent centrifuge are shown below in Figure 1.

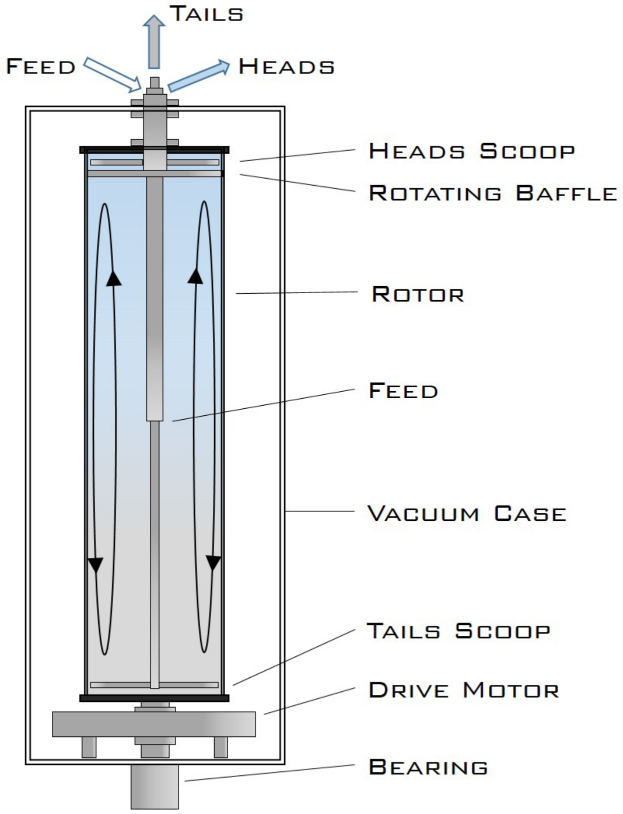

Figure 1. Cross-Section of a typical uranium enrichment centrifuge. The rotor is balanced on a bearing inside a vacuum casing. Feed gas enters the rotor volume at the center via a series of concentric tubes along the axis. The product gas, or heads, is removed from near the top of the rotor while the waste, or tails, is removed through a scoop near the bottom. A baffle shields the product scoop from the countercurrent flow. The axial difference in temperature of the process gas and the interaction of the rotating gas with the feed gas and the waste scoop all contribute to the countercurrent flow.

The separative ability of a centrifuge depends largely on the gas flow, and the flow field from the solution of the hydrodynamic equations provides the necessary velocity profiles to solve the diffusion equation.[3] Cohen, Von Halle, and others have shown that the hydrodynamics and isotope transport in the rotor can be decoupled.[4,5] Numerous applications exist for higher fidelity flow and transport models of gas centrifuges, ranging from optimization of commercial enrichment machines to nonproliferation monitoring. The overarching motivation for this research is improved nonproliferation focused modeling of existing and emerging state enrichment capabilities, and this project is designed to provide another tool for the academic, political, and international safeguards communities to assess a state's ability to leverage their enrichment capability for other than declared purposes.

Flow and Transport Simulations

A variety of new techniques developed as a result of this project may prove useful to the separation phenomena and nonproliferation communities desiring to continue the conversation about enrichment capability and the time required to achieve significant quantities of highly enriched material. Based on the Onsager Equation with Carrier-Maslen end conditions, the CurvSOL hydrodynamics code uses a finite elements algorithm to solve the linearized sixth-order partial differential equation describing the flow in the volume of the rotor of a gas centrifuge. The countercurrent flow in the centrifuge is generated as a result of gas feed and withdrawal, mechanical scoop interaction, and a rotor wall temperature gradient. CurvSOL models each of these drive mechanisms by inclusion of mass, momentum, and energy source terms in the governing equations. The results are compared to those from Pancake, an existing code employing an eigenfunction expansion solution technique to solve the Onsager equation. Due to proprietary concerns and the potential sensitive nature of separation applications, the international community published the design information for two fictitious centrifuges, the Rome and the Iguaçu, in an effort to enable collaboration and information sharing. Comparison of the axial mass flux, streamfunction, upflow ratio, and flow profile efficiency demonstrates excellent agreement between the CurvSOL and Pancake solutions for both the wall temperature gradient and scoop drive mechanisms, as well as the overall mass flux profile, for both the Rome and Iguaçu designs. Results of CurvSOL simulations with and without the pancake approximation suggest that the radius of the rotor plays an important role in the effect of wall curvature on internal flow.

The axial mass flux profile derived from the hydrodynamic solution provides the necessary input information for a finite differencing scheme to obtain a numerical solution of the diffusion equation to predict the transport of uranium hexafluoride molecules in the xPort code. The set of equations governing the isotope transport is not readily solvable using analytic means, and different solution methods have been developed to arrive at approximations for both the axial concentration gradient and overall concentration profile. The generally accepted method of approximation describes the axial variation of the radially averaged concentration. As shown in Figure 2, the newly developed two-dimensional concentration field approximation allows for separative performance calculation at all points along the radial direction. Comparison of the two-dimensional solution averaged at each axial plane and the one-dimensional radial averaging solution shows that while the results from both methods differed by an atomic fraction of 6% at select axial planes near the middle of the rotor, the averages at the endcaps agree to within 2%. Systematic variation of the feed rate and targeted cut values generates two-dimensional performance maps of separative work and separation factor for use in centrifuge enrichment cascade models.

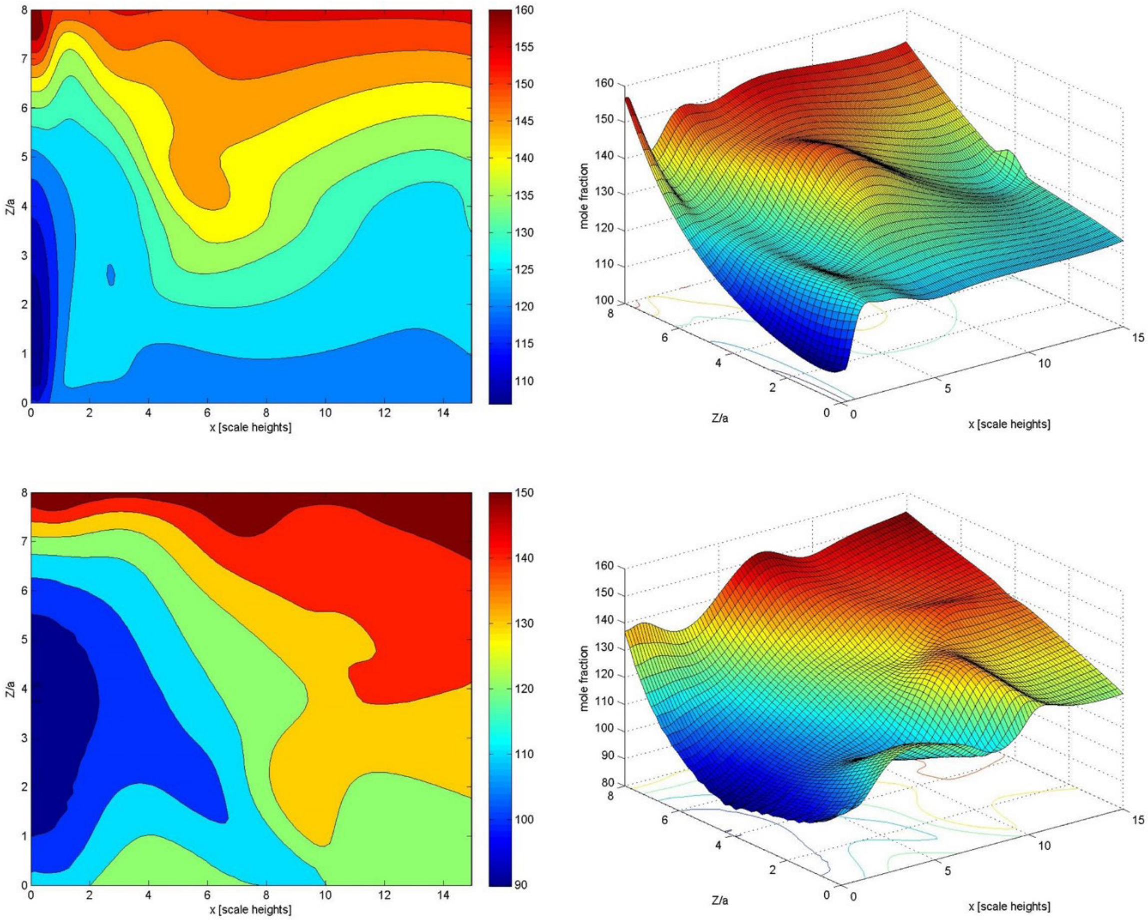

Figure 2. Two-dimensional contour plots of the results of the finite difference code approximating the solution to the diffusion equation in the Iguaçu machine with simulations run at a 500 m/s wall speed. Corresponding three-dimensional continuous surface plots are shown on the right. Two axial mass flux fields for each wall speed were used to run the simulations: the mass flow derived from the solution generated by the CurvSOL code (top) and the Pancake code (bottom).

Cascade Modeling

The separation achieved by a single separator unit varies significantly between the types of separators. Additionally, the operational throughput of a single unit is so small that accumulation of appreciable quantities of enriched material requires a large number of separators connected in parallel banks, or stages, and a number of stages then connected in series. This arrangement of enrichment units is known as a cascade. The enrichment capacity of a centrifuge cascade facility is often estimated based on the achievable amount of Separative Work Units (SWU) of the aggregate number of machines in the facility rather than capacity of the actual cascades existing in the facility. While a cascade can be designed to approximate the necessary ideal cascade, SWU-based breakout timeline estimates do not take into consideration the time required to configure the equipment or the inherent error introduced when the ideal cascade is squared-off. A fixed-plant method produces a breakout timeline estimate based on existing cascades[6]. The *CascSCAN* code utilizes a modified version of the *FixedCascBin* cascade solver for binary separation, the information contained in the performance map, and cascade design parameters to scan over the range of possible cascade configurations and determine the time to necessary to achieve a significant quantity of weapons grade uranium[7].

The number of cascades in each step of a 4-step batch enrichment process designed to enrich natural uranium to weapons grade varies depending on the amount of feed material and desired product rate. The Joint Comprehensive Plan of Action (JCPOA) of 2015 limited the Islamic Republic of Iran to 5,060 operational IR-1 centrifuges installed at the Natanz Gas Centrifuge Enrichment Plant (GCEP). The agreement limited existing inventory of 3.5% low enriched uranium (LEU) to 300 kg and authorized no inventory of 20% in any form other than fabricated fuel. Additionally, the JCPOA limited the number of centrifuge cascades at the Natanz GCEP to 30. Figure 3 shows the results of the *CascSCAN* code, scanning over all possible configurations of 5,060 centrifuges arranged in 173 machine cascades in either a full 4-step process or the modified 3-step process using an existing inventory of approximate 3.5% LEU. The tails of each step are recycled and included into the feed of the lower step. These simulations considered inclusion of existing inventories of 3.5% and near 20% (defined as 19.75% for analytic purposes when solving the cascade gradient equations) initially fed to the cascade at a rate that would exhaust the inventory in one year. Once the initial breakout estimate was obtained by exhausting the inventory in one year, the simulation process was repeated and the existing inventory fed at a rate to exhaust the supply in the amount time determined by the initial estimate. The data obtained was then analyzed to determine a mean and minimum time to achieve one significant quantity of WGU, and the resulting plots are shown below in Figure 3.

Though the simulations vary the amount of near 20% UF6 introduced in step 3, the estimated breakout times do not include any time to convert near 20% fuel assemblies into uranium hexafluoride (UF6). Figure 3 depicts the minimum achievable breakout time for the 3 and 4-step batch processes for different levels of near 20% inventory. The plots in Figure 3 were created using the *CascSCAN* code with performance maps for the IR-1 centrifuge generated via the semi-empirical method developed by Migliorini, et al.[6,7] Figure 4 depicts the results of the Iguaçu machine subject to the same constraints described in the JCPOA case study for the IR-1 centrifuge. Two performance maps were used, one based on the one-dimensional radial averaging method of separation calculation and one based on the two dimensional numerical method. In all cases, the two-dimensional numerical method based performance map predicts a lower breakout time, in some cases the difference is on the order of months.

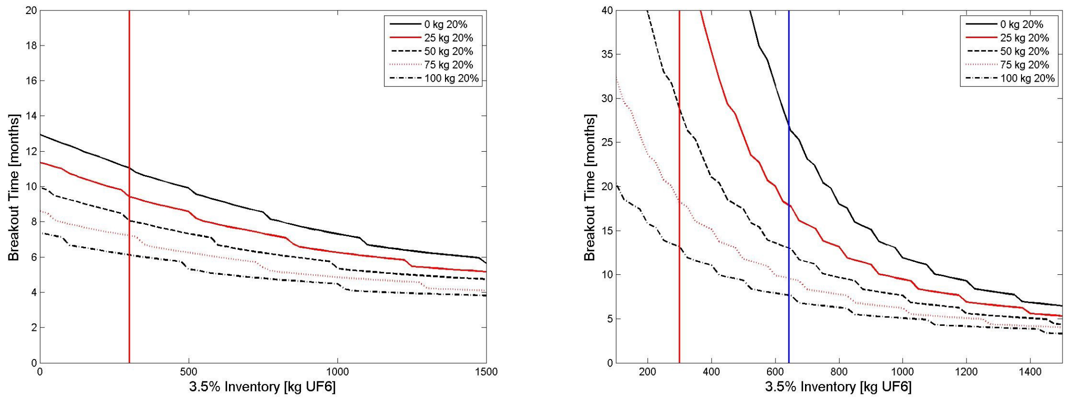

Figure 3. 3-step and 4-step breakout estimates. Results of 3-step (right) and 4-step (left) batch process simulations with existing inventories of 3.5% LEU ranging from 100-1500 kg and near 20% LEU ranging from 0-100 kg. The vertical red line depicts the maximum inventory of 3.5% allowed by the JCPOA. The vertical blue line represents the minimum inventory of 3.5% necessary to use the 3-step process with no inventory of near 20%.

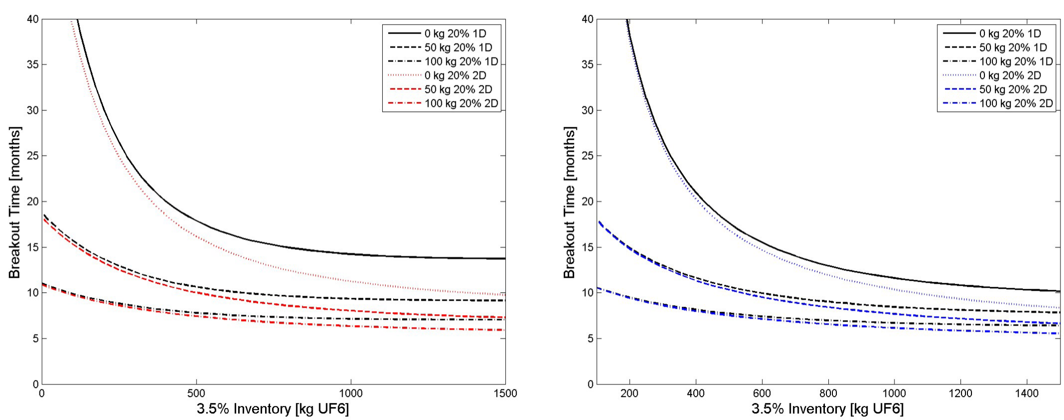

Figure 4. Comparison of the 3-step (right) and 4-step (left) batch processes with performance maps derived from the one-dimensional radial averaging technique derived by Cohen (black curves) and the two-dimensional xPort code solution (red and blue curves). In all cases, the maps based on the xPort results predict lower breakout estimates.

Summary

A variety of new techniques are presented which may prove useful to the separation phenomena and nonproliferation communities desiring to continue the conversation about enrichment capability and the time required to achieve significant quantities of highly enriched material. *CurvSOL* simulations suggest that the radius of the rotor has a significant impact on the character of the internal flow. The two-dimensional approximation of the concentration field shows that the radial variation in the smaller, slower centrifuges is not insignificant, questioning the assumptions underlying the traditional radial averaging technique. Finally, the systematic variation of the feed rate and targeted cut values allows for the mapping of the separative performance and separation factor, and theses performance maps are employed in cascade analysis software packages. The performance maps based on the *xPort* results predict lower breakout times as additional inventory of enriched material is added to the feed stream. These codes and techniques provide new tools to extend the conversation about cascade performance and "breakout" potential for nuclear capable states.

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National Security Applications Experimentation at the National Ignition Facility

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The National Ignition Facility (NIF) at Lawrence Livermore National Laboratory (LLNL) is the largest and most energetic laser facility in the world. Operational in 2008 and approximately three football fields in size, NIF is the world's largest optical instrument and the most precise and reproducible laser ever constructed. Its 40,000 optics guide, reflect, and amplify its 192 beams onto a fusion target the size of a pencil eraser. Capable of delivering more than 400 trillion watts over 2-4 nanoseconds, NIF generates extreme states of matter with temperatures exceeding 180 million degrees Fahrenheit and pressures in excess of 100 billion times Earth's atmosphere.[1] NIF presently has four mission areas: Inertial Confinement Fusion, High Energy Density Physics, Discovery Science, and National Security Applications (NSA). One of its goals is to ensure the reliability of the nation's nuclear weapons stockpile in the absence of underground testing.

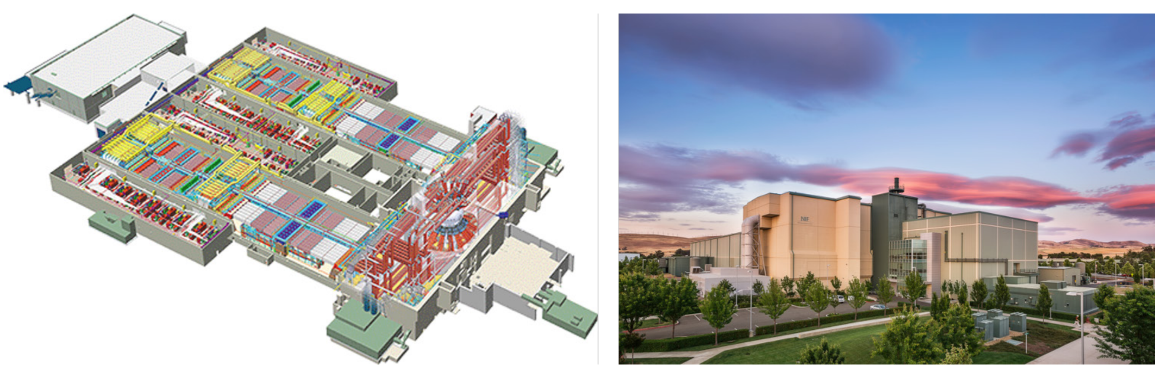

Figure 1. Interior schematic (left) and exterior (right) of the National Ignition Facility at Lawrence Livermore National Laboratory.

NSA experiments are typically allotted 14 shot days per calendar year. Depending on the complexity of the experiment, one to three shots are conducted per day. Customers for these shot days include the U.S. Navy, the Missile Defense Agency, Sandia National Laboratories, the United Kingdom Atomic Weapons Establishment (AWE), and experiments sponsored by the Defense Threat Reduction Agency (DTRA) and the National Nuclear Security Administration (NNSA). The primary purpose of this work is to generate nuclear weapon effects environments in lieu of underground effects testing to evaluate the survivability of strategic and ballistic missile defense systems. As a Department of Energy (DOE) User Facility, customers are only required to fund engineering support for the design, development, diagnostics, and fielding of the experiment.

Experiments pertaining to national security are prioritized by the Joint National Security Applications Council (JNSAC), which was formally stood up in 2013 and is jointly chaired by the DTRA Nuclear Technologies Department and NNSA NA-10. Each year, NIF issues a call for proposals in the national security arena. A group of subject matter experts from the Department of Defense (DoD), DOE labs, and academia, which constitute the JNSAC Peer Review Panel (PRP), then assesses the proposals. The proposals are evaluated based on the following criteria: Facility uniqueness (i.e. Why NIF?), mission impact, and technical merit/quality of the proposal and its associated modeling and simulation plan. The PRP numerically ranks the proposals and places each into one of three tiers: Tier 1 – Facility time for data acquisition using existing test infrastructure, Tier 2 – Facility time requiring new or modified diagnostics and/or test platforms, and Tier 3 – New proposal development requiring significant technical support for evaluation and refinements of new scientific concepts. Lastly, the PRP provides these groupings in terms of prioritized recommendations to the JNSAC co-chairs for validation and approval. Historically, the number and shot time requests of proposals exceed the shot allocation for NSA.

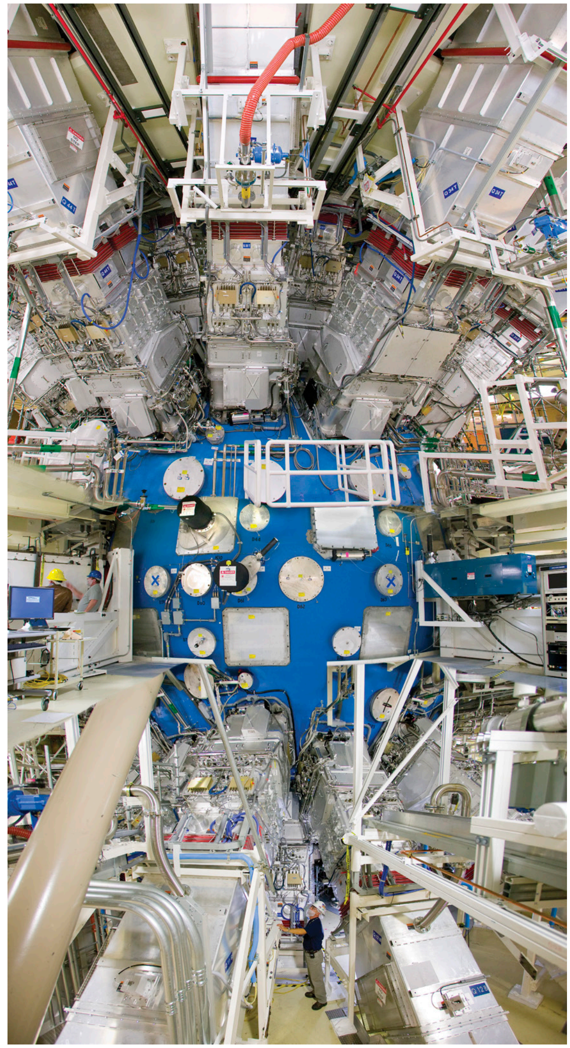

Figure 2. National Ignition Facility target chamber, which measures ten meters in diameter. Note that floors on the horizontal plane were digitally removed to show some of the 48 upper and lower laser beam final optical assemblies at the target chamber.

The role of DTRA is to develop test environments and test platforms for the evaluation of nuclear weapon effects on behalf of DoD and, as a result, much of DTRA's experimental work on NIF focuses on development of new diagnostics and x-ray sources in support of emerging Service test requirements. For example, DTRA funded the development of the X-ray Transport and Radiation Response Analysis (XTRRA) test cassette to support Service and Missile Defense

Agency experiments, the NIF X-ray Spectrometer (NXS), and is funding research for the continuing development of new and better x-ray sources to support test needs. XTRRA allows for uniform exposure of six samples to x-ray environments of interest and the resultant data is then used to validate modeling and simulation tools. NXS is a time-resolved, high-spectral-resolution x-ray spectrometer and is available to all users, but particularly for NSA shots, as a core facility diagnostic. DTRA also sponsors development of novel x-ray sources such as low density metallic foams (as shown in figure 4 below) that support development of new sources to reach relevant energy levels at increased conversion efficiencies. At the request of the DoD, the NIF chamber included a large port that will allow for the insertion of DoD test objects such as reentry bodies and missile defense inceptors as shown in Figure 5. In addition, in a joint project with NNSA and AWE, DTRA is developing a future surrogate large-area test capability for strategic system materials and structures to characterize the effects of impulse resulting from cold x-ray environments. Other NSA experiments look at material response to thermomechanical shock, system-generated electromagnetic pulse, neutron effects, model validation of radiation effects, and nuclear forensics, making NIF a vital national security asset.

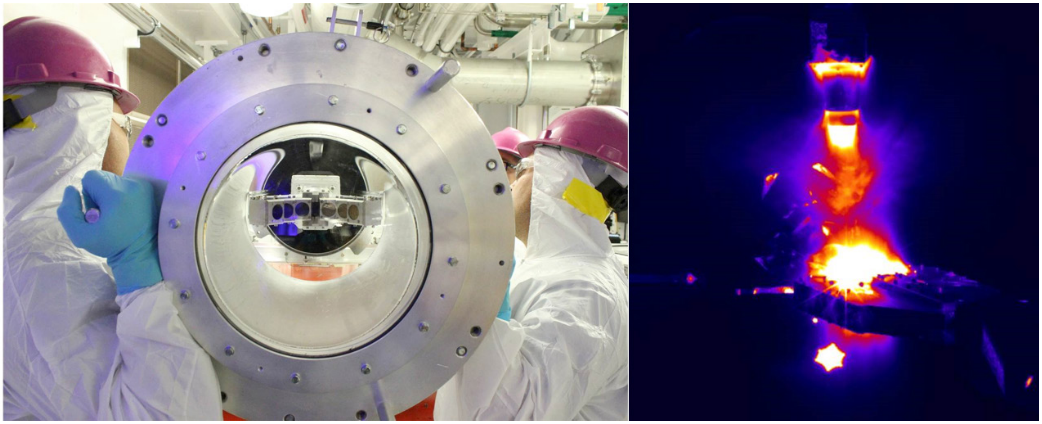

Figure 3. Insertion of the X-ray Transport and Radiation Response Analysis test cassette into a National Ignition Facility Diagnostic Insertion Module (left) and the subsequent data acquisition shot (right).

Figure 4. National Ignition Facility X-ray Spectrometer (left) and ultra-light copper foam x-ray targets (right).

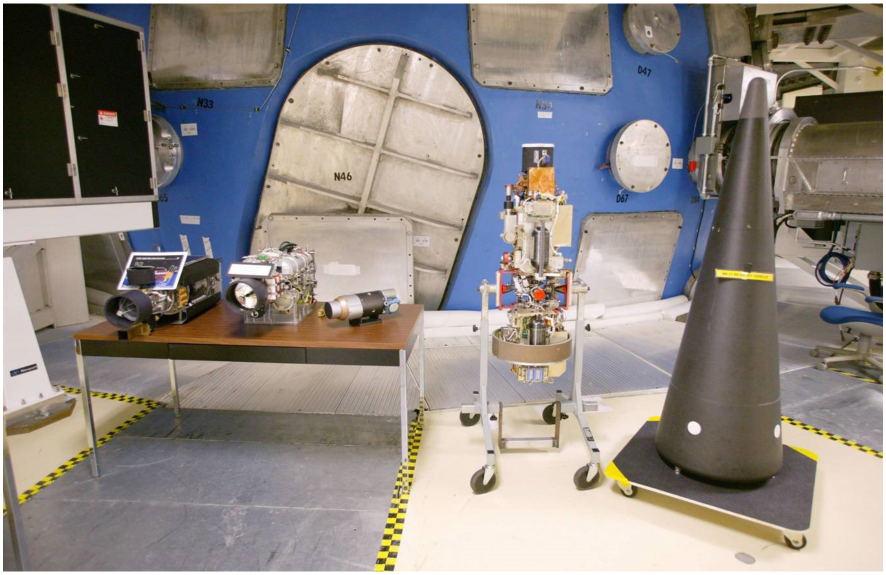

Figure 5. A large access port in the National Ignition Facility test chamber was added to allow for the insertion of Department of Defense test objects up to two meters in length.

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Southeast Asia Nuclear Proliferation

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Southeast Asia is a region that has experienced a range of adversities including colonial rule, interstate war, internal violence, terrorism, organized crime, environmental disaster and financial collapse. It is also a region advancing forward with resurging economic growth, increasing populations and a greater importance in global trade. The adversities mentioned, however, continue to complicate these advancements. Southeast Asia's importance on the world stage tends to focus on its strategic position as a shipping and transit corridor. The threat of terrorism and rise of extremism in the region often overshadows the advantages of this strategic position. Few associate Southeast Asia with Weapons of Mass Destruction (WMD). While it may seem unlikely for any countries within the Association of Southeast Asian Nations (ASEAN) to consider developing WMD, the threat associated with WMD exists. While there are conditions where countries would choose to develop WMD, the threat is more likely associated with proliferation risks. This is especially true as ASEAN countries develop alternate nuclear fuel sources to support their growing economies. This influx of nuclear technology into a region experiencing the adversities mentioned should cause concern for world leaders. This article will explore some conditions associated with ASEAN countries developing WMD and highlight potential risks associated with nuclear technology.

Most thoughts of WMD in Southeast Asia tend to focus on the U.S. military use of chemical and toxin weapons during the Vietnam War and the alleged use by Vietnam of Soviet chemical and toxin weapons against the Hmong villagers of Northern Laos.[1] However, accusations of chemical weapon use by other ASEAN countries persist as do admissions of countries seeking nuclear weapons. Over the past 30 years, activists and journalists have claimed that the Burmese Army employed chemical weapons (CW) and possibly even biological weapons (BW) against domestic opponents. While these allegations are unproven, Burma did apparently experiment with CW production in the 1980s.[2] Even though the ASEAN countries have all signed up to the Treaty on

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the Non-Proliferation of Nuclear Weapons (NPT), the Chemical Weapons Convention (CWC), and the Biological and Toxins Weapons Convention (BTWC), they have made little progress in implementing the relevant treaties, conventions, and protocols to counter proliferation risks. With the exception of Singapore, Southeast Asia's export control systems remain unsophisticated and weak. Highlighting the proliferation risk are Burma and Vietnams' alleged programs and the development of indigenous petrochemical industries in countries such as Brunei.[3] The threat of these countries developing chemical weapons is low; however, the chemical industry is dual-use in nature. The processes and precursors for legitimate peaceful chemical purposes can also serve military purposes. This is also true for nuclear power.

The interest in nuclear power in most ASEAN countries reflects a growing demand for energy and the concern over the economic cost and environmental impact of other fuel sources. For example, coal is dirty, hydropower dams upset fragile ecologies and displace communities, and transporting natural gas is expensive. Even with these fuel sources, Indonesia has never generated enough power for its country. Adding to the energy demand problems, since 2003 Indonesia has been a net importer of oil and is no longer a member of Organization of the Petroleum Exporting Countries (OPEC). The energy problem is so serious that nearly 10,000 companies maintain their own power generation capacity. This is unconnected to public power grids and produces nearly a third of the electricity consumed in the country.[4] Vietnam also has rapidly expanding energy demands that will double in just 4 years and it depends on unreliable hydropower for 40% of its electrical output.[5] To continue to grow and continue to be attractive for foreign direct investment, these economies require sustainable and reliable energy. Most ASEAN countries see nuclear energy as a solution and some such as Vietnam, Indonesia and Thailand have filed plans with the International Atomic Energy Agency (IAEA) to develop nuclear power reactors in the next 5 to 10 years. While the IAEA has strict guidelines for the operation of nuclear reactors, the introduction of nuclear reactors above the research level in this region increases the risk of proliferation due to the dual-use nature of nuclear technology. While proliferation of this nuclear technology is the greatest risk, some conditions could drive ASEAN countries to seek nuclear weapons.

The Treaty on the Southeast Asian Nuclear-Weapon-Free-Zone prohibiting the development, manufacture, acquisition, or testing of nuclear weapons anywhere within the region came into force in 1997. Historically, however, President Sukarno, Indonesia's leader from 1945 to 1967, considered the option of developing nuclear weapons in the mid-1960s following China's detonation of a nuclear device in 1964.[6] Additionally, many suspect that Burma has long sought nuclear weapons even though, in September 2011, the Burmese ambassador in Vienna told the IAEA that Burma had neither the capacity nor the intention to develop nuclear weapons.[7] Despite assurances, growing hostilities over resources in the South China Sea for example could convince countries such as Vietnam to hedge against China and develop a weapon as a bargaining chip. Other conditions include prestige and nationalism, potentially driving the desire to be the first Southeast Asian country to join the nuclear club. A historical feeling of mutual distrust also prevails in Southeast Asia and even though ASEAN states do not explicitly identify each other as security threats, many weapons systems procured by the region's armed forces are externally oriented.

Systems such as submarines, missile boats and supersonic combat aircraft are instruments of conventional interstate warfare, not internal conflicts, which ASEAN states tend to identify as threats that are more significant.[8] Apart from their traditional antagonisms however, ASEAN countries recognize the linkages of their economies and seem to develop these weapon systems more for prestige and status than for regional war.

As discussed, the proliferation of dual-use materials associated with nuclear technology remains the greatest risk in the region. The proliferation risk associated with Southeast Asia stems in part to the "ASEAN way" of non-interference and a resentment of export controls, viewing them as barriers to economic development. Additionally, most ASEAN countries are active participants of the Non-Aligned Movement (NAM), and are critical of non-universal nonproliferation mechanisms that limit the access of non-nuclear weapon states (NNWS) to technologies for the peaceful uses of nuclear energy. Indonesia in particularly is skeptical of multilateral export control regimes, viewing them as impeding the flow of technology to the developing world.[9] These regimes, however, are in place to prevent the spread of nuclear technology to potentially dangerous actors. As countries such as Vietnam, Indonesia and Thailand begin developing nuclear power, a serious question is whether these nuclear newcomers choose to develop the fissile material production capabilities such as uranium enrichment or plutonium reprocessing. This would give them the ability to produce weapons-usable nuclear materials heightening the risks to proliferation or theft. Some countries such as Saudi Arabia have promised to forgo such capabilities. Others such as Vietnam have left the question open.[10] Fissile nuclear material and the associated technologies are prime proliferation risks and while countries cooperating with the IAEA for nuclear reactors may sign agreements to control exports, enforcement of these controls is paramount and ASEAN countries have a weak record with enforcement. In addition to the proliferation risk, other concerns are the physical safety and security of nuclear reactors.

The safety and security risks to nuclear reactors come from a variety of sources including a general inability to maintain safe operations, the threat from insurgent or terrorist groups, and natural disasters. Nuclear energy opponents as an example emphasize Indonesia's general inability to safely manage public infrastructure. In 2006 alone, official statistics show that aircraft incidents occurred at the rate of one every nine to ten days and two trains crashed or derailed each month in Indonesia. In 2007, two fatal air crashes prompted the European Union and the United States to ban all Indonesian airlines from their skies. Additional concern comes from a string of natural disasters that reflect the region's precarious geography and geology. In addition to the tsunami that killed more than 160,000 Indonesians in late 2004, damaging earthquakes have struck the island of Java, on which the government plans to construct its first nuclear plant. In 2006, one earthquake killed more than 5,000 people, and in 2007 another damaged an oil refinery seriously enough that it had to be shut down temporarily.[11]

The inability within some ASEAN countries to safely manage public infrastructure heightens the risk posed by terrorists and insurgents desiring to target nuclear power reactors or attempt to obtain nuclear material. There is no shortage of violent militant groups operating in the region including Muslim separatists in the southern Philippines, Aceh in Indonesia, and the southern provinces of Thailand. Additionally, the

Jemaah Islamiyah (JI) has proven to be a serious threat to the security of the region, especially in Indonesia.[12] Despite active counter-terrorism efforts, JI has successfully conducted numerous terrorist attacks since the Bali bombing in 2002, including the most recent 2009 bombing of the Ritz-Carlton and Marriott in Jakarta. Terrorist attention has also focused on the region's nuclear research reactors and future nuclear power plants as potential for acquiring nuclear and radioactive materials. Reports reveal the involvement of key individuals from Southeast Asia in the nuclear black market and in Al Qaeda's attempts to acquire WMD materials and expertise from Southeast Asia.[13]

In addition to the various terrorist organizations in Southeast Asia, several groups operate as organized criminal groups thriving in black market trade. The Chinese "Triads", Japanese "Yakuza", and the military-style ethnic groups controlling drug production in the gold triangle operate throughout Southeast Asia. ASEAN nations have generally failed to keep pace with regional crime developments due the absence of strong bilateral and regional law-enforcement cooperation.[14] The overlap between terrorist and crime networks remains uncertain in Southeast Asia but there is the potential for collusion between these networks to gain access to WMD materials and/ or technology for use internationally or domestically within the region.

As discussed, terrorists or armed militant groups could find targeting nuclear reactors appealing and the demonstrated security and safety lapses throughout Southeast Asia increases their potential for success. Additionally, Southeast Asian geography and its role in the global economy render it vulnerable to maritime terrorist attacks. Southeast Asia serves as the shipping and transshipment connector with 25 percent of world trade and 50 percent of the oil supply transiting through the Malacca Strait.[15] The Strait has chokepoints congested with over 200 cargo ships slowly navigating narrow and shallow channels on a daily basis. Based on the number of ships operating in the region, a terrorist organization having obtained nuclear material or even an improvised nuclear device would find it relatively simple to conduct an attack in those channels. Even greater economic damage would occur from the detonation of a dirty bomb (a conventional bomb configured to disperse radioactive material) smuggled in a container ship into a port such as the Singapore harbor. The global economic impact from a closure of the port of Singapore could easily exceed US $200 billion per year from disruptions to inventory and production cycles.[16] In 2003, Singapore's Deputy Prime Minister warned that with the hardening of land and aviation targets, the threat of terrorism is likely to shift to maritime targets, especially commercial shipping. Further highlighting the threat, detained members of Jemaah Islamiah admitted that shipping in the Malacca Straits had been a possible target.[17]

In conclusion, there are several risks associated with introducing nuclear technology into Southeast Asia. While the likelihood of ASEAN countries developing nuclear weapons is low, the proliferation of the material and/or technology is high. Mitigation of the proliferation risks is possible through enforcement mechanisms, however ASEAN countries are historically and culturally opposed to strict export control measures, identifying them as impediments to economic growth. Additionally, the safety and security of nuclear reactors is of concern due to the poor record of some ASEAN countries in maintaining their infrastructure and the risks associated with natural disasters. With numerous terrorist, militant and organized criminal groups operating in Southeast Asia, nuclear reactors, materials and technology will become attractive targets. Additionally, the shipping and transshipment characteristics driving Southeast Asian economic development are highly vulnerable to attack. An attack on ports or maritime corridors, especially with WMD related materials, would cause significant damage not only to Southeast Asia but also to the global economy.

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NATO at 70: Reflection on the Alliance's Contribution to Peace

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"There is at least one thing worse than fighting with allies–and that is to fight without them"
– Sir Winston S. Churchill

Introduction

Through its vigilance, the North Atlantic Treaty Organization (NATO) has kept the peace in Europe for nearly three quarters of a century. Soon after World War II ended, geopolitical tensions between the United States and the Soviet Union led to the Cold War. The Cold War was marked by the Soviet Union's attempts to expand its dominance further west into Europe as well as other regions, and the United States' counter-attempts to contain the spread of Communism. Nowhere were the United States' efforts to thwart Soviet expansion more prominent and successful than in Western Europe. First by extending economic aid with the Marshall Plan (officially the European Recovery Plan) in 1948 and then by creating a military alliance with the formation of NATO in 1949.

As NATO members recently observed the 70th anniversary of the Alliance's founding with events in Washington, D.C. and at NATO headquarters in Brussels, Belgium, it is certainly time well spent to refresh our understanding of the history and the mission of the Alliance, look at how consensus contributes to its success, and finally how the US and the other members of NATO achieve CBRN defense interoperability.

History

Established with the signing of the North Atlantic Treaty in Washington, D.C. on April 4, 1949 by 12 nations, NATO now has 29 members with several other nation states aspiring to become

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members. The 2010 Strategic Concept defines NATO's core tasks as: collective defense, crisis management and cooperative security. Remarkably, in the history of the Alliance, the Treaty has never been amended or modified.

Something that isn't always obvious is that NATO is both a political and a military Alliance. To the layperson, the role of NATO is likely only seen as a military organization, with its most well-known highlight being Article 5 – Collective Defence: that an " armed attack against one or more of them in Europe or North America shall be considered an attack against them all…" As important as its contribution to peace as a military alliance dedicated to the common defense of its members, the Alliance is also known for its contribution to democracy and democratic ideals. The nation states in NATO are all democracies. Indeed, several of the nation states that are now members of the Alliance were once the antithesis of a practicing democracy and were either defeated Axis Powers during World War II, or members of the Warsaw Pact, NATO's Cold War adversary made up of the communist nations in Eastern Europe led by Russia.

NATO's door remains open because of Article 10 which states that membership is open to any "European State in a position to further the principles of this Treaty and to contribute to the security of the North Atlantic area." The Republic of North Macedonia is currently in the process of acceding to NATO as a member state. The Alliance agreed to invite the country to become a member as soon as a mutually acceptable solution to the issue over the country's name was reached with Greece. Following the resolution, North Macedonia was invited to start accession talks. The Accession Protocol was signed on 6 February 2019. Once the Protocol is ratified by each of the 29 Allies, North Macedonia will become a member of NATO. Bosnia and Herzegovina was invited to join the Membership Action Plan (MAP). The MAP is a NATO program of advice, assistance and practical support tailored to the individual needs of countries wishing to join the Alliance. Participation in the MAP does not prejudge any decision by the alliance on future membership.

Operating by consensus as a matter of course, there are no votes taken of NATO members. The Alliance operates on consensus, after discussion and consultation among member countries. Consultation between member states is therefore at the heart of NATO since Allies are able to exchange views and information, and discuss issues prior to reaching agreement and taking action. Consultation is embodied in Article 4 of the North Atlantic Charter, which states that "The Parties will consult together whenever, in the opinion of any of them, the territorial integrity, political independence or security of any of the Parties is threatened." Although achieving consensus may seem like a slow, unyielding process, strategically there are several benefits to why operating on consensus is ideal.

First, it projects unity to the rest of the world. Any mission that NATO takes on comes with the knowledge that it has the backing of every member of the Alliance. This fact is something that no adversary should disregard. In total, the Alliance's 29 members have more than six million personnel under arms in their active and reserve military forces.[1]

Second, it ensures all members have a voice in Alliance matters regardless of each nation state's size or wealth. In terms of area, the smallest Alliance member is Luxembourg. The largest member of the Alliance, Canada, has a land mass more than 3800 times the size of the smallest. In terms of gross domestic product (GDP), the United States, with a nearly 21 trillion dollar GDP, is more than five times larger than that of the next member, Germany, at 3.4 trillion dollars. There are many other metrics that can be used to describe how each member of NATO is uniquely large at something or small at something else. Yet, despite these disparities, each member knows that their voice will be heard and must be considered when it comes to implementing the will of the Alliance.

And finally, it commits the members to shared risks, responsibilities, and benefits. There is likely no more sober a thought for members of the Alliance than knowing that their decisions will commit their militaries to operations spanning the spectrum from training assistance and peace-keeping to multi-domain warfare.

NATO recognizes the importance of partnerships as a way to project stability and strengthen security outside of NATO territory. To this end, the Alliance has developed a network of partnerships with non-member countries from the Euro-Atlantic area, the Mediterranean and the Gulf region, and other partners across the globe. Partners are part of many of NATO's core activities from shaping policy to building defence capacity, developing interoperability and managing crises. Partners contribute to NATO-led operations and missions. As contributors to those missions, partners are invited to shape policy and decisions that affect those missions, alongside Allies.

CBRN Defense Interoperability within NATO

The primary body tasked with coordinating CBRN defense for the Alliance is the Joint CBRN Defence Capability Development Group (CDG). U.S. engagement in the NATO CDG, which is led by USANCA, supports the Army Campaign Plan 2019+ Line of Effort (LOE) #4, Strengthen Alliances and Partnerships. As DoD's Action Agent, USANCA shapes the CDG's program of work consistent with DoD CWMD and CBRN Defense goals and objectives. Prior to 2012,

Figure 1. The new NATO Headquarters in Brussels, Belgium. First opened in 2017, it now houses the military and diplomatic delegations from the 29 member nation states. It is located across the street from the old NATO HQs.

there were two separate working groups that addressed CBRND standardization: the Joint CBRN Defence Operations Working Group responsible for operational standardization; and the Joint Capability Group on CBRN Defence that addressed materiel standardization. Due to NATO reform in 2012, both groups were merged to create the NATO CDG. NATO reform also brought the Training and Exercise Panel, previously called the CBRN Training Working Group under the NATO Training Group, into the fold of the NATO CDG.

The CDG accomplishes its mission through the work of its seven chartered panels. Each of these panels focuses on a unique aspect of CBRN defense that contributes to the overall success of the CDG and its interoperability mission. Interoperability is a vital component of Army's plan to strengthen alliances and partnerships. It is the ability to routinely act together coherently, effectively, and efficiently to achieve tactical, operational, and strategic objectives.[2] Figure 1 shows how the CDG fits into the overall NATO organization, along with its seven subordinate panels.[3]

Overall, the CDG is responsible for the publication of more than 50 standardization agreements (STANAGs) and standardization recommendations (STANRECs), each of which contribute to CBRND interoperability of the Alliance. The STANAGs and STANRECs are assigned to one of the seven CDG panels based on the specific topics. And it is the responsibility of the panel to conduct periodic reviews of each of these documents, at least once every five years, to determine if the document needs a revision or is still current.

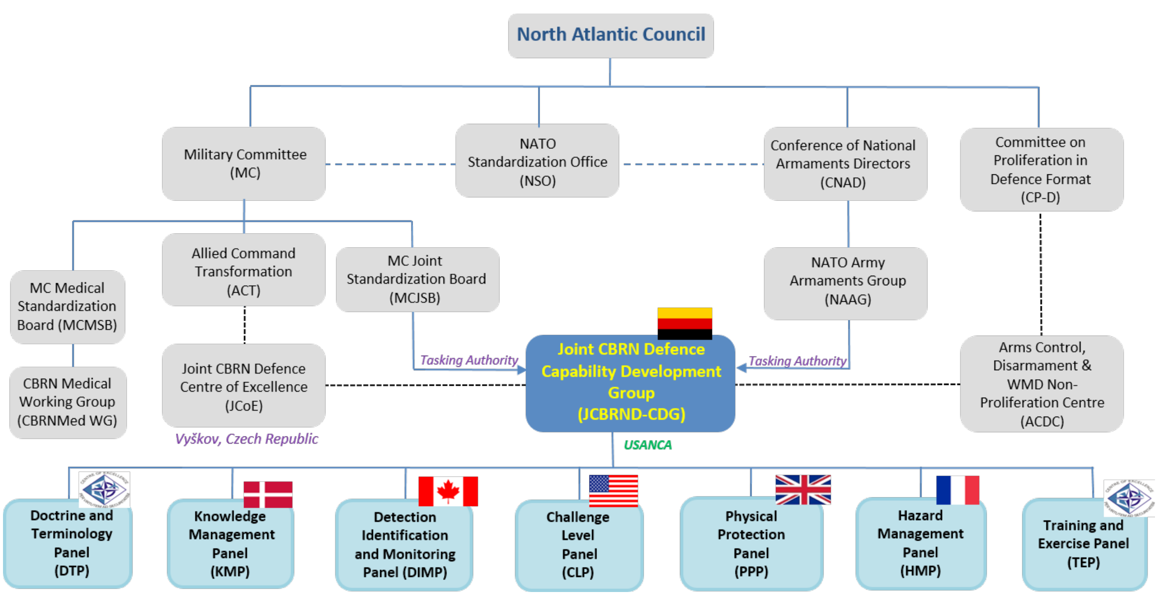

Figure 2. NATO Organizational Structure showing the CBRND CDG and the seven panels. The national flags indicate the nations that chair the CDG and its seven subordinate panels.

Figure 3. The US Delegation during the spring 2019 CDG Meeting at the new NATO HQs. L-R, back row: LTC Mark Hartell, (OSD), CWO5 Brian Barksdale (J8/JRO), MAJ Jay Kopcha (NATO Allied Command Operations), COL Dirk Plante (USANCA); front row: Mr. Tim Bauer (NSWC-Dahlgren), Ms. Bhavna Mukundan (OSD), Ms. Anita Walker (USANCA), LTC Jonathan Harvey (JFC-Brunssum).

Other NATO Activities for Increasing CBRN Defense Interoperability

In addition to the CDG, several other organizations have a role in contributing directly to CBRN defense interoperability within NATO. The CDG maintains situational awareness of the activities of these organizations and invites them to participate in CDG activities. These organizations are the CBRN Medical Working Group, Joint CBRN Defence Center of Excellence, and the Combined Joint CBRN Defence Task Force.

The CBRN Medical Working Group is responsible for standardization documents related to health protection against CBRN weapons. They coordinate their work closely with the CDG and attend the CDG's semi-annual plenaries.

The Joint CBRN Defence Centre of Excellence, located in Vyškov, Czech Republic, is manned by thirteen NATO members, along with Austria. These members offer their recognized expertise and experience in CBRN defense activities to the other NATO members as well as partner nations. These CBRN defense activities include education, training and exercises; operational support; and NATO transformation.

The Combined Joint CBRN Defence Task Force is led by a member of the Alliance on a rotational basic and is a part of the NATO Response Force (NRF). It is the Alliance's quick response capability to prevent, protect and recover from WMD attacks or CBRN events. The Task Force consists of the CBRN Joint Assessment Team (JAT) and a CBRN Defence Battalion, and is trained and equipped to deploy for armed conflict as well as natural and man-made disasters.

Conclusion

At 70, NATO is the most successful alliance in history. NATO Secretary General Jens Stoltenberg addressed a joint session of the United States Congress on 3 April 2019 to commemorate the occasion and remarked:

NATO is the most successful Alliance in history because we have always been able to change as the world changes. And because, despite our differences, we are united in our commitment to each other. NATO is an alliance of sovereign nations. United by democracy, liberty and the rule of law. By a person's right to live their life in the pursuit of happiness. Free from oppression. Values that lie at the heart of the United States. And at the heart of NATO.

With the past and present security challenges that NATO has faced, it is remarkable to recognize how successful the Alliance has been at guaranteeing the freedom and security of its members. And when Europe and North America are faced with challenges in the future, it is reassuring to know that NATO, through the commitment of its member states, will be ready to respond to them.

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2. The Army Strategy, pg. 10, October 2018. Accessed at https://www.army.mil/e2/downloads/rv7/the_army_strategy_2018.pdf, 5 April 2019.
3. For a more detailed examination of the CDG and its seven panels, see the article, "North Atlantic Treaty Organization Standardization: The Key to Successful Alliance Operations," in the Countering WMD Journal issue 15.

My Experience Earning a Doctorate Outside of Advanced Civil Schooling

LTC Joseph Kling
United States Strategic Command

Introduction

Given the variety of experiences for FA52s, it's possible that career advice from an FA52 is applicable to only a small number of people. So, I make no attempt to offer this as advice, just sharing my doctorate education experience in the hopes that some part of it is helpful to anyone seeking alternatives to earning a degree outside of the ACS route.

It was difficult, but rewarding in completing the individual requirements and ultimately earning a Doctor of Engineering (D.Eng.) in Engineering Management from The George Washington University (GW). Only time will tell whether the effort was truly worth it. Regardless, I am glad I did it, but acknowledge that the timing, program, and motivation were just right for me.

While I was investigating further professional credential options, I had two assumptions in the back of my mind for a career after the military. First, I assumed that I would continue to work in a nuclear enterprise- or a CWMD-related field after retirement. Second, although several factors will ultimately play a part, I assumed my work after retirement would not be with DoD (or at least I wanted to position myself that way), so I personally placed value on something-other-than-military education and a desire to differentiate myself from other military officers retiring at 20+ years

Motivation

One of my first motivations to start looking more seriously into some type of further professional development (e.g., PMP, PE, online degree program) was a sense that I wasn't doing enough to prepare for a career after retirement. There was only so much Netflix I could handle during the

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week and I had too much of what I considered excess time that I was wasting. I felt that before I came to a decision point on whether to retire, I wanted to have something different–some type of civilian credential or further schooling, potentially in the systems engineering area dealing with management of large projects, technological innovation, or large system integration.

I previously considered a Ph.D. program, but believed that could decrease my chances for promotion given that I would miss three years of OERs. Although I was thinking of the longer term beyond retirement, I did not want to rule out the possibility of a promotion in the shorter term. This was during the time of retention boards and a general feeling that the Army was getting smaller. My personal feeling was that I would be decreasing my promotion potential by foregoing a full slate of O-5 OERs. I also personally felt that at my age and military experience, my value in a future career would be in my military experience, not deep, Ph.D.-level knowledge in a particular field. So my decision at that time was to pursue another assignment rather than a Ph.D. program.

Choosing the George Washington Program

Despite my decision to pursue another assignment rather than advanced civil schooling, I had a strong desire for further professional development after about one year in my new assignment. I first looked at other alternatives such as PMP, PE, or CHP certification, but those alternatives did not seem right to me at that time for one reason or another.

The timing, structure, and content of the GW program I chose seemed a better fit for me. The GW program would be a two-year program, meaning I could complete it before moving to my next assignment. There were also no in-person class or symposium requirements which would not be possible from my assignment in Germany. From my time zone, the first year of classes would be 3:00 PM to 11:00 PM on Saturdays–I could participate in synchronous online classes for just those 8 hours, with the rest of time up to me to complete assignments and engage with other students and professors as needed. Also, time commitments for the second year of praxis research were left almost completely up to me with one mandatory advisor meeting per month. The program was also a structured program. As a cohort program with a group of students progressing through similar requirements, I felt it was much more likely for me to complete it in two years rather than risk dragging on indefinitely (the risk of running longer did exist, as some in my cohort finished 7-8 months later and some did not finish at all). As far as content, the program I chose was not my optimal choice–I would have preferred a systems engineering program – but the timing and motivation lined up with the D.Eng. in Engineering Management program. (In alternating years, GW offered a systems engineering Ph.D. with a similar structure in a 2-year cohort, but I did not want to wait another year.)

Doctor of Engineering in Engineering Management Program at The George Washington University

I began this program with a group of about 25 students in August 2016 with a target graduation date of August 2018. From one of the initial GW information papers from May 2016:

- The program was a Department of Engineering Management and Systems Engineering (EMSE) weekend online program leading to the award of the Doctor of Engineering (D.Eng.) degree with a field of study in Engineering Management.

- The program was offered through the EMSE Off-Campus Programs Office under the direction and supervision of Professor Shahram Sarkani, Ph.D., P.E., Faculty Advisor and Academic Director.
- The intent of the online, cohort-style program was to enable full-time working professionals to pursue advanced study in a focused environment alongside like-minded fellow students.

Doctor of Engineering Degree

According to the GW EMSE Programs Office description, the Doctor of Engineering (D.Eng.) degree in Engineering Management:

- Addresses the widespread need for practitioners who can apply the knowledge they gain in the program of study in a business or technical environment.
- Unlike a Doctor of Philosophy (Ph.D.) degree student, whose fundamental research leads to foundational work that is published in archival professional journals and contributes to the basic understanding of a field, the D.Eng. student must engage a practical problem and take a new approach to its resolution, applying advanced engineering management theories and practices to recommend a useful solution. Research toward the D.Eng. is applied, rather than basic. The D.Eng. empowers the student, who is likely already to be a practicing engineer, to create advanced, hands-on treatments of complex engineering management problems.
- Course work culminates in the praxis, a research document wherein the student proposes a practice-based solution to a problem of their own choosing, that could be used by practicing engineers.

Curriculum

The program consisted of 45 credit hours divided into a classroom phase of ten graduate-level, three-credit-hour courses, and a research phase culminating in a praxis paper and successful defense before a committee of examiners. Work on the praxis comprised 15 credit hours. The classroom courses are listed below and varied slightly from the initially proposed courses (due to the tight scheduling required to fit ten classes over the course of a year, a late conflict for one of the instructors caused a change to one of the classes.)

- Uncertainty Analysis for Engineers
- Advanced Knowledge Management
- Technological Forecasting and Management
- Logistics Planning
- International Technology Commercialization
- Entrepreneurship
- Data Analysis for Engineers and Scientist
- Risk Management Process for the Engineering Manager
- Managing E-Commerce Technologies
- Engineering Praxis

Classroom Phase

There were five classroom-phase sessions in all, with two classes per session of approximately nine weeks. Classes met on Saturdays with each one lasting three and a half hours and course sessions lasting nine weeks. Morning classes met from 9:00 am to 12:30 pm (Eastern) and afternoon classes met from 1:30 pm to 5:00 pm (Eastern). I was stationed in Germany at the time, so class times ran from 3:00 pm to 11:00 pm (Central European), which turned out to make weekend travel still possible. Classes were also generally not held over major holiday weekends (e.g., Memorial Day, Thanksgiving), which eased family vacation planning. Throughout the program, classes were required to be taken in lock-step with the cohort and could not be taken out of sequence. The timing made for long days,, but limited class participation to a single period and left time management up to me for the rest of the week to study, complete assignments, or reach out to instructors or other students for help.

Instructors and course content were advertised as being identical to the main campus programs. Course administration was supported by Blackboard web-based course management software. All classes met online via WebEx and were recorded to enable future viewing. WebEx enabled students to see and hear the instructor; view slides, videos, whiteboard notes or drawings, and shared screens; and ask questions or interact with other students by voice or chat. In addition to writing requirements throughout the year, exams (typically a mid-term and final exam) were administered via remote exam proctoring through software installed on students' personal computers.

Praxis Phase

Students propose and defend the praxis they wish to undertake during the final course of the classroom phase. According to the EMSE Student Guidelines, the praxis synthesizes engineering theory and practice to create value for practical use–it should engage an existing, real engineering management issue and take a new approach to its resolution. A successful praxis is required to apply engineering theory and practice to recommend a worthwhile solution and must use the latest engineering management concepts and tools. In my praxis, I used Bayesian network modeling to investigate a critical material supply network. Some sample research areas proposed by the EMSE department included: engineering management in a health care environment, innovations in the management of technology, management of large-scale projects, managing technological innovation, and product & process improvement.

After approval of the praxis proposal, I worked over the next 12 months with principal and alternate advisors in developing my research and completing the praxis. The program required a monthly research meeting where I presented an update on progress, challenges, and path forward. Advisors evaluated the monthly meetings through verbal and written feedback as well as a red-amber-green ratings of progress. Successive red ratings over two meetings or an overall red assessment for a semester (equivalent to two 9-week periods) would indicate insufficient progress and terminate the program. Time management during the research phase was completely up to me, which made fitting the program into work and family schedules easier (although not easy).

Once complete, I defended my praxis before an examination committee consisting of my advisors, two EMSE faculty members assigned by GW, and an outside advisor required by GW but selected by me. After successfully defending my praxis before the members, the committee recommended the degree of Doctor of Engineering.

Although the many long hours were personally rewarding in the end, the timing, program, and motivation were just right for my circumstances. If you are investigating a similar or related program, I'd be happy to talk about my experience if you have any questions.

Dedicated to Research, Education, Excellence

Army Officer Continues to Give Back to Country, Sciences

Sarah Marshall
Uniformed Services University

AFRRI

Uniformed Services University

When Army Lieutenant Colonel Robert McMahon enlisted in the Army in 1990, his plan was to proudly serve and fulfill his four-year obligation, then transition out of the military. He didn't expect to find himself working for such extraordinary leaders, who would inspire him to stay in the Army for 29 years and counting. Today, he strives to continue giving back to his country, the sciences, and the next generation of military leaders.

In addition to the opportunities McMahon has had to work with such exceptional leaders, subordinates, and peers, he's also been given many opportunities to sharpen his expertise in nuclear engineering and radiobiology – areas that he says are necessary and in high demand.

In 1996, McMahon was awarded the Army's Green to Gold Scholarship, allowing him to commission as an officer after earning his Bachelor of Science degree in Biochemistry. As a biochemist, he was commissioned in the Army's Chemical Corps. This led to the opportunity for him to serve in the Army's Technical Escort Unit, and deploy in support of the Iraq Survey Group during Operation Iraqi Freedom. After gaining that experience, and with the help of great mentors, he was selected for Functional Designation in FA 52 – Nuclear and Counterproliferation, where he was able to focus his research on nuclear weapons effects.

McMahon then went on to earn a Master of Science degree in Nuclear Engineering from the Air Force Institute of Technology, in 2012, before being assigned to the Uniformed Services University's (USU) Armed Forces Radiobiology Research Institute (AFRRI) that same year. Since then, McMahon has worked at AFRRI with a team of brilliant scientists on cutting-edge research,

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studying the medical effects of ionizing radiation and radiation countermeasures.

Inspired by the scientists and leadership at AFRRI, he recently applied to pursue a doctoral degree from USU's Molecular and Cell Biology (MCB) graduate program. The program is led by many investigators, whose laboratories students can elect to perform their dissertation research. Students are expected to publish their results in peer-reviewed journals, and are also encouraged to present their work at seminars within the university, as well as at national and international meetings. Graduates of the program have gone on to postdoctoral positions in highly regarded academic and private sector labs throughout the country.

Figure 1. Uniformed Services University Campus

For McMahon's utilization tour, he applied for and was selected to serve on the faculty of the United States Military Academy at West Point in the Department of Chemistry and Life Science. He takes pride in serving the Army in this capacity, he said, and is looking forward to the opportunity to teach the next generation of Army leaders.

But for now, McMahon keeps busy with his graduate studies and research. Under the guidance of his advisor, Dr. Alexandra Miller, an AFRRI senior scientist, McMahon is studying the effects of radiation on bioprinted tissue – collaborative research being conducted by USU's 4-Dimensional Bioprinting, Biofabrication, and Biomanufacturing (4D Bio3) program and AFRRI. "We are on the cutting edge of science," he said.

Although this career path was not exactly what he would have anticipated, McMahon says he wouldn't have had it any other way. "I am very fortunate that in every aspect of my military career, I have been surrounded by exceptional leadership," he said. "It is that exceptional leadership that has made me the Soldier I am today, and I can only begin to repay that debt by providing exceptional leadership to tomorrow's leaders."

For more information about USU, its graduate education programs, and AFRRI, visit www.usuhs.edu.

Book Review: On Limited Nuclear War in the 21st Century

Edited by Jeffrey A. Larsen and Kerry M. Kartchner

MAJ Christopher Mihal
Air Force Institute of Technology

On Limited Nuclear War in the 21st Century (hereafter referred to as OLNW), published in 2014, purports to be a holistic look at limited nuclear as a concept and argues that the U.S. is unprepared to engage in such a conflict. The collected essays span the scope of the U.S. nuclear experience, divided into three sections – Assessing the History of Limited Nuclear War, Managing the Risk of Nuclear War in the 21st Century, and Confronting the Challenges of Nuclear War in the 21st Century. As with any collection of essays from various authors, the quality is uneven, and some authors' assertions directly contradict others, which weakens the overall thesis of the collection. Given the broad scope of the book and limited space, this may have been unavoidable, although conversely, the scattershot presentation is valuable in permitting the reader to ponder these issues on their own with a multifaceted approach. As such, it is a worthwhile volume for anyone with interest in the CWMD community, though with the caveat that the book offers the reader far more questions than answers.

The primary weakness of this volume is the inability to come to a solid conclusion on how to define limited nuclear war – a question that, to be fair, has plagued U.S. policymakers for decades. Thomas Schelling notes in the forward that, aside from zero nuclear use, there is no easy answer for countries to agree on what would constitute acceptable use in war, and authors such as Bruce Bennett note in "On US Preparedness for Limited Nuclear War," whatever we may consider a "limited" nuclear war, "it is not clear that an adversary would perceive such attacks as limited," which immensely complicates matters. The U.S., with thousands of warheads, may consider the expenditure of say, a dozen weapons to be limited, an emergent nuclear nation such as North Korea would consider that an attack equivalent to the majority of its stockpile, and could respond accordingly. Many authors cite Henry Kissinger's 1956 tome "Force and Diplomacy in the Nuclear Age," which has valid arguments for its time, although most authors fail to note Kissinger himself discredited that particular work later in life.

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Furthermore, while the study of U.S. nuclear policy during the Cold War has historical significance, it has little relevance in modern warfare. Russian doctrine has evolved considerably since the Cold War, and, disappointingly, OLNW seldom delves into Russia's hybrid war/so-called "Gerasimov Doctrine," and how a limited nuclear exchange could fit in to Russian plans. Given the Soviet Union's stated doctrine was to respond to any nuclear use with full-scale retaliation, Cold War nuclear doctrine was thus shaped by this very possible outcome, and so the concept of limited nuclear war, while discussed, never really took hold. Indeed, George Questor posits in "The End of the Nuclear Taboo?" that U.S. discussions of limited nuclear war may have in and of themselves been put forth not to seriously implement such a doctrine, but to convince the U.S.S.R. that U.S. talks of escalation were more than just talk, and thus discussion of limited nuclear war became but one more facet of deterrence.

Of much more usefulness to modern policymakers and military planners are the latter two sections of the book, particularly Kartchner and Gerson's "Escalation to Limited Nuclear War in the 21st Century," and Foerster's "Deterrence, Crisis Management and Nuclear War Termination." These sections present a range of scenarios that the U.S. could face where a very limited nuclear capability would be beneficial, though as is usual with these sorts of works the opaqueness of how other countries would respond is rather canned or simply unknown, thus making it difficult to assess the verisimilitude of the scenarios. Nevertheless, these latter essays shine light on several ways in which nuclear weapons could be used – by the U.S., an adversary, or another nation – that might not lead to total nuclear war.

The final challenge this book faces is one that it mostly fails to address. If nuclear weapons are a "red line" and their use is only permitted for an existential national crisis, then there is no such thing as limited nuclear use, and enforcing counter-proliferation efforts worldwide should readily gain international support, as have efforts against chemical and biological weapons. If, on the other hand, one chooses to argue that there are limited uses for nuclear weapons, in effect placing them on the same level as more conventional weapons, this casts doubt on the sincerity and motives of counter-proliferation efforts. While the rationale for use of the weapons is much more nuanced than this, international perceptions are of massive importance when it comes to nuclear weapons, and most nations are understandably wary of any use of nuclear capabilities when the sole use of nuclear weapons in warfare was the culmination of a total war.

Despite its shortcomings, OLNW is a valuable addition to any CWMD library. It is particularly intriguing to read this book in the post-2018 Nuclear Posture Review era, coupled with the recent declaration by both the U.S. and Russia to withdraw from the Intermediate-Range Nuclear Forces Treaty. One hopes to never have to apply the lessons of this book, but one would be remiss not to be aware of them.

Nuclear Effects Test Looks to Validate Radiation Computer Model

MAJ William Bosley
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The US Army Nuclear and Countering Weapons of Mass Destruction Agency (USANCA) conducted a series of tests in late February at the White Sands Missile Range (WSMR) Survivability, Vulnerability, and Assessment Directorate's (SVAD) Fast Burst Reactor (FBR) facility with the support of the 16th Brigade Engineer Battalion (16th BEB) from the 1st Stryker Brigade of the 1st Armor Division (1st AD), the Defense Threat Reduction Agency (DTRA), Los Alamos National Lab,

Figure 1. A team from USANCA and the 1st AD 16th BEB take measurements around the Stryker NBCRV in preparation for radiological testing at the White Sands Missile Range Fast Burst Rector.

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and SVAD staff. The tests bombarded a M1135 Stryker Nuclear, Biological, Chemical, Reconnaissance Vehicle (NBCRV) from the 1st AD 16th BEB with varying levels of ionizing radiation from the FBR, comparing measurements at specific locations around the vehicle with measurements in the same locations when the vehicle was located outside the radiation area. The study was done to evaluate the vehicle's abilities to protect the crew in a radiological environment and evaluate a new methodology for calculating how well a vehicle will protect the crew from radiation using computer models.

The associated computational modeling project, led by the DTRA's Research and Development Directorate, uses design data from the vehicle manufacturer to simulate how an Army tactical vehicle would perform in a radiological environment. By using a computer model in place of testing, the Army and the Department of Defense are able to save time and money, while still collecting data needed for decision makers. Instead of running reactor tests on each type or vehicle variant, modeling is sufficient for operational planning.

The data collected in the Stryker test re not just about the Stryker crew, but also for the larger Army, as commanders and other leaders will need to know what their forces are capable of doing to lead them effectively in a hostile environment. The information is for planners and leaders who make decisions in operations in order to figure out where Soldiers should and should not be during operations involving radiation.

While multi-domain operations in a nuclear environment are a primary concern for the Army, since we live in a modern era, a radiological or nuclear event could come from other sources. This type of testing is important not only for defense, but also for other emergency response situations in support of civil authorities.

Figure 2. Solders from the 1st AD 16th BEB recover radiation detection equipment between test shots from the Stryker NBCRV at the White Sands Missile Range Fast Burst Reactor.

Looking Back: The USANCA Officer of 40 Years Ago

Author Unknown
Submitted by MAJ Andrew Lerch
United States Army Nuclear and Countering WMD Agency

During a recent housecleaning of legacy files, FA52 Proponency came across a document outlining the expectations of USANCA officers circa 1978 and it was included in the Agency welcome packet at that time. Fundamentally, those roles and responsibilities remain unchanged to this day. The text is below.

THE ROLE OF THE USANCA OFFICER

The US Army Nuclear and Chemical Agency (USANCA) is a relatively small organization with a myriad of responsibilities. The potential effects on the US Army of the manner in which we carry out these responsibilities and the results we achieve are far reaching. The individual officer assigned to the Agency, therefore, must carry out his duties as a competent member of a dedicated and respected team.

A newly assigned officer will be charged with a specific area of interest in which he is expected to become the expert in the US Army. The acquisition of this degree of proficiency requires voluminous reading, dedicated study, an inquisitive mind and an acceptance of the fact that there is always more to be learned. This learning process must include, however, subject matter not necessarily related to defined and assigned responsibilities. It is incumbent upon the USANCA officer to seek and absorb any and all information that may be made available concerning his military profession. He is an officer first; a nuclear or chemical specialist second.

Duties in all areas require continuous interaction with personnel, of more extensive experience and higher grade, representing the Army, the DOD, the DOE and civilian industry. The more qualified and knowledgeable they are, the more they will defer to the judgment of the USANCA officer who has properly prepared himself and lucidly presented his case. The experts from outside the Agency with whom the USANCA officer interfaces, in fact, rely on the Agency and its members for information, opinions and positions that may well be decisive in the successful accomplishment of a given task. The responsibility for accuracy, candor and discretion is apparent.

The extensive knowledge, military, scientific and technical, required of and possessed by the Agency as a whole, is usually applied by individual officers working in concert. But the nature of the Agency's mission dictates that on occasion individual officers, especially during their frequent travels, convey and apply this knowledge independently of the rest of the team. In such cases, officers represent the Agency, and perhaps higher headquarters of the US Army. These representational responsibilities are critical to the accomplishment of this Agency's mission. Education, military experience and personal application qualify the officer for this role. His demeanor, personality and self-confidence will enable him to fulfill it.

An aspect of the USANCA officer's role that requires mentioning is initiative. Continuous examination of the what, how and why associated with assigned and derived tasks should reveal new approaches to old problems, new problems created by old solutions and new areas that require investigation and analysis. The Agency's business has its genesis in the minds of thinking men. The USANCA officer needs to think, imagine and explore.

Another aspect requiring mention deals with communications. Oral and written communications are the means used to “sell” the products of the mind. They are the life blood of the corporate Agency. Briefings, reports, letters and informal presentations are frequently the product of individual officer efforts only and as such must evidence the same quality as the thinking and analysis which they reflect. There is another facet communications that is equally as important–reception. The USANCA officer will be constantly exposed to the thoughts and ideas of others. Those who visit the Agency and those visited by Agency members all have something worthwhile to communicate. It is essential that the USANCA officer “listen sharp,” filter the worthy from the not so worthy and call forward from his memory bank that which is beneficially relevant. Good ideas are not the exclusive property of their originators, except when they fail to find expression.

Lastly, the USANCA officer must direct his efforts toward mission accomplishment with the full knowledge that he is solely responsible for the way in which he expends time and energy resources. It is accepted that he will err; however, it is expected that he will thereby profit.

Within the Agency, there is always a ready and interested audience to serve as a sounding board for an idea or concept. Support and assistance are readily available. The USANCA officer will receive in direct proportion to his giving. His satisfaction will be derived from his participation in a dynamic, militarily important field. His rewards will flow from the successful completion of assigned tasks.

How to Submit an Article to the Countering WMD Journal

The Countering WMD Journal is published semi-annually by the United States Army Nuclear and Countering WMD Agency (USANCA). We welcome articles from all U.S. Government agencies and academia involved with CWMD matters. Articles are reviewed and must be approved by the Countering WMD Journal Editorial Board prior to publication. The journal provides a forum for exchanging information and ideas within the CWMD community. Writers may discuss training, current operations, and exercises, doctrine, equipment, history, personal viewpoints, or other areas of general interest to CWMD personnel. Articles may share good ideas and lessons learned or explore better ways of doing things. Shorter, after action type articles and reviews of books on CWMD topics are also welcome.

Articles submitted to *Countering WMD Journal* must be accompanied by a written release from the author's activity security manager before editing can begin. All information contained in an article must be unclassified, non-sensitive, and releasable to the public. It is the author's responsibility to ensure that security is not compromised; information appearing in open sources does not constitute declassification. The *Countering WMD Journal* is distributed to military units and other agencies worldwide. As such, it is readily accessible to nongovernment or foreign individuals and organizations. A fillable security release memorandum is provided at http://www.belvoir.army.mil/usanca/.

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