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About the cover: United States Military Academy cadets training in a tunnel complex during the Applied Radiation Detection Exercise. Photo credit: Cadet Elington Ward, USMA class of 2022, Co I-4 from the Cadet Media Group.

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Director Notes

COL Benjamin Miller
Director, USANCA

Welcome all to the *CWMD Journal*. I am COL Ben Miller, the new Director of USANCA. COVID-19 dominates all of our headlines. The CWMD community is no different. This pandemic is shaping our professional and personal lives.

Before I share my background and command perspective, I would like to first recognize Brigadier General John Weidner's outstanding leadership as the outgoing Director of USANCA. BG Weidner expanded USANCA's role into many areas that directly contribute to the CWMD mission while always maintaining focus on what is critical for the Army. BG Weidner is an outstanding Soldier and a personal mentor.

I come to USANCA after serving for four years in the Department of Energy's National Nuclear Security Administration (NNSA). While assigned to NNSA, I had the opportunity to direct NNSA's investments in long-term research for technologies in the detection of illicit activities by terrorists and nations to acquire nuclear weapons. I also led the Agency's investments in capabilities that further the nuclear weapon stockpile modernization programs. Military officers bring an operational focus to NNSA and they leave with an appreciation of the complex environment in fielding nuclear weapons.

Prior to my assignment at NNSA, I managed the Defense Threat Reduction Agency's portfolio to develop technologies for warfighters operating on a nuclear battlefield. Previously, I led a team analyzing conventional weapons effects on adversarial strategic facilities at the Defense Intelligence Agency. I also taught physics at the United States Military Academy, West Point. Before coming to the nuclear and countering weapons of mass destruction field, I was an armor officer in command deployments to Iraq and headquarters commands at Fort Riley, KS.

The Army, the United States, and the entire world are dealing with the COVID-19 virus. The Department of Defense (DoD) is protecting the force while simultaneously aiding the Nation. USANCA has a pivotal role in this immediate need. Our Agency is uniquely qualified to support the Army and DoD. Let there be no doubt, this pandemic has similar effects to a weapon of mass destruction. Whether the result of an attack by a traditional adversary or a naturally occurring pathogen, our response to the biological threat and the hazards it poses to the operating environment is the same.

Our competitors seek to exploit our divisions. Russia is spreading misinformation about the origin of COVID-19. China is providing aid in Africa and Italy; they are also taking issue with Taiwan's status with the World Health Organization. North Korea continues to test its ballistic missiles while our allies' and our government's attention is turned towards protecting the population. What moves our adversaries will make against our allies and forces deployed around the world are unknown.

As members of the CWMD community we have a unique role and responsibility to assist with combatting the COVID-19 crisis. Our understanding of pathogens, transmission, and safety precautions makes us invaluable advisors to decision-makers. In preparing the Army to operate in WMD-compromised battlefields, we are ready for this challenge. It is at this time that our technical expertise and advice must be at its best. This is an opportunity for the CWMD community and USANCA to show our strength.

I appreciate your hard work and resolve. It is in these trying times that your excellence as CWMD professionals shine through.

Nuclear Modernization and Arms Control: Options and Their Consequences

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U.S. nuclear modernization is not merely a heavy metal exercise. Decisions about nuclear modernization are embedded in a larger context that includes questions of: the requirements for deterrence and other aspects of military strategy; domestic as well as international politics; budgets; arms control; and nonproliferation. This study examines the problem of U.S. strategic nuclear modernization under the assumption that New START limitations on the numbers of warhead and launcher deployments by Russia and the United States will carry forward into (at least) the near-term future. We describe and evaluate three alternative U.S. force postures relevant to a New START constrained arms control regime. We also consider whether a U.S. or Russian shift to a dyad without long-range bombers, instead of their currently deployed triads of land based, sea based and air launched weapons, can meet the U.S. requirements for survivably deployed and crisis stable weapons systems. The implications of various arms control regimes for nonproliferation are also considered: can survivable and crisis stable Russian and American long-range nuclear weapons systems affect other states' future choices about nuclear proliferation, or, to the contrary, are future U.S.-Russian agreements mostly irrelevant in the multipolar nuclear world of the second nuclear age?[1]

SETTING THE STAGE

The United States and Russia are both committed to large-scale nuclear modernization programs for their strategic and theater nuclear forces and their nuclear command, control, and communication (NC3) systems. For the United States Air Force (USAF) this modernization effort is of particular importance because it is planned to include development and acquisition of at least 100 B-21 stealth bombers, 1,000 Long Range Stand Off cruise missiles (LRSO), and 400 Ground Based Strategic Deterrent (GBSD) intercontinental ballistic missiles (ICBM).[2] In effect, the USAF is planning to replace two legs of the nuclear triad over the next three decades. During the Cold War, both nuclear warheads and delivery vehicles were replaced every 10–15 years. When the

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Cold War ended and the Soviet Union collapsed, the United States broke this regular replacement cycle for a generation. Russia followed much the same path as it tried to recover from political and economic turmoil. This leaves the current modernization effort in both countries—unprecedented in their scope—leaving some observers and analysts uncertain as to the consequences for strategic stability.

While Russia and the United States have a long history of negotiating past agreements to reduce the size and scope of their respective nuclear arsenals and to maintain some transparency with respect to the deployment of delivery vehicles and weapons, the current Russian modernization effort and Russian aggression in Europe are leaving many to wonder what the future may hold for strategic stability. Russian violation of the Intermediate Nuclear Forces Treaty (INF) and subsequent American withdrawal from the treaty are a sign of arms control's failure as President Trump weighs the continued utility of New START, which expires in 2021.[3]

The politically clouded atmosphere between the U.S. and Russia, fraught with uncertainty since Russian President Vladimir Putin decided to annex Crimea and destabilize eastern Ukraine in 2014, leaves future arms control in a state of suspended animation. This is particularly challenging for the USAF as it faces tight budgets and the need to recapitalize both its conventional and nuclear forces.[4] Thus, there is little room for error in making acquisition choices.[5] All of this is being done in a rapidly changing strategic environment where major technological developments are reshaping the strategic environment as hypersonic weapons, artificial intelligence, quantum computing, and other game-changing technologies must be taken into account as they have the potential to make the existing modernization plan obsolete.[6]

Neither Russia nor the United States has unlimited funding to support nuclear and other military modernization. Both nations have a shared interest in reducing the degree of international nuclear danger and in maintaining a certain "special relationship" as the two leading nuclear superpowers. The following discussion examines the feasibility of post–New START strategic nuclear arms reductions through the lens of political and strategic developments. It is not a comprehensive look at arms control, Russian nuclear doctrine, or technological development, but a prospective look at the possible implications for strategic consequences of further reductions in operationally deployed strategic nuclear weapons within the context of ongoing political and technological developments.

NEW START OR NEW IMPASSE

Since the INF Treaty has ended, New START stands alone as the remaining nuclear arms control treaty between the United States and Russia. The New START agreement of 2010 (entering into effect in 2011) required Russia and the United States to reduce the numbers of operationally deployed strategic nuclear weapons to no more than 1,550 on no more than 700 delivery vehicles by 2018.[7] Both nations met this requirement through a slightly different mix of delivery systems and warheads. Today, both nations deploy a triad of long-range bombers, intercontinental ballistic missiles (ICBMs), and submarine-launched ballistic missiles (SLBMs). In the analysis that follows, hypothetical, but not unrealistic, forces are generated for American and Russian New START–compliant strategic nuclear forces for the period 2020-2025.[8]

By comparison, American and Russian forces at lower than New START levels are also generated and analyzed. These forces are then subjected to first strikes and the numbers of surviving and retaliating second strike warheads are estimated under each of four conditions of operational readiness and launch preparedness: (1) generated alert and forces are launched on warning [GEN, LOW]; (2) generated alert and forces are launched after riding out the attack [GEN, ROA]; (3) day-to-day alert and forces are launched on warning [DAY, LOW]; and (4) day-to-day alert and forces ride out the attack [DAY, ROA].[9] In addition, outcomes are also tabulated for various force postures for each state, in addition to the canonical triads of long range land based, sea based and air delivered munitions.

It is worth noting that the nuclear exchange model used to develop these results offers a best approximation of what might occur in specific and discreet scenarios. It should not be seen as an attempt to offer high fidelity in the event of nuclear exchange. As with conventional conflict, the number of unknown variables that can affect real events is significant. The nuclear exchange model employed here does, however, spur our thinking on nuclear strategy and policy. It gives us the ability to contemplate a variety of options and consider what may be in the realm of the possible.

The results of this analysis for the two states' surviving and retaliating forces under a peacetime deployment limit of 1,550 warheads for each state appear in Figure 1.

The data summarized in Figure 1 shows that American and Russian forces with peacetime deployment limits of 1,550 operationally deployed strategic nuclear weapons can meet the requirements, not only for assured retaliation, but also for flexible use against a variety of target sets including opposing forces, command-and-

	Balanced Triad	No ICBMs	No Bombers	SLBMs Only	Balanced Triad	No Bombers	No SLBMs	ICBMs Only
GEN, LOW	1279	1201	1279	1166	1303	1335	1335	1352
GEN, ROA	955	1201	955	1166	931	816	557	501
DAY, LOW	946	781	975	781	796	920	1271	1352
DAY, ROA	622	781	651	781	367	350	493	501

Figure 1: U.S. – Russia Surviving and Retaliating Warheads 1,550 Deployment Limit
Source: Figures 1 through 5 by authors, based on Arriving Weapons Sensitivity Model (AWSM@) developed by Dr. James Scouras. Dr. Scouras is not responsible for its use here.

control nodes, and war-supporting targets. In the canonical case of "generated alert, riding out attack," each state can also withhold some retaliating weapon for future strikes as a means of intra-war deterrence and support for war termination. These numbers of surviving weapons can also support adaptability, in the sense of flexibility and resilience, for surviving forces. These simulated results are, of course, dependent on the USAF and USN conducting their mission as expected. Should Clausewitz's "fog and friction" of war intervene or Talib's "black swan" enter the scenario, the results may no longer hold.[10]

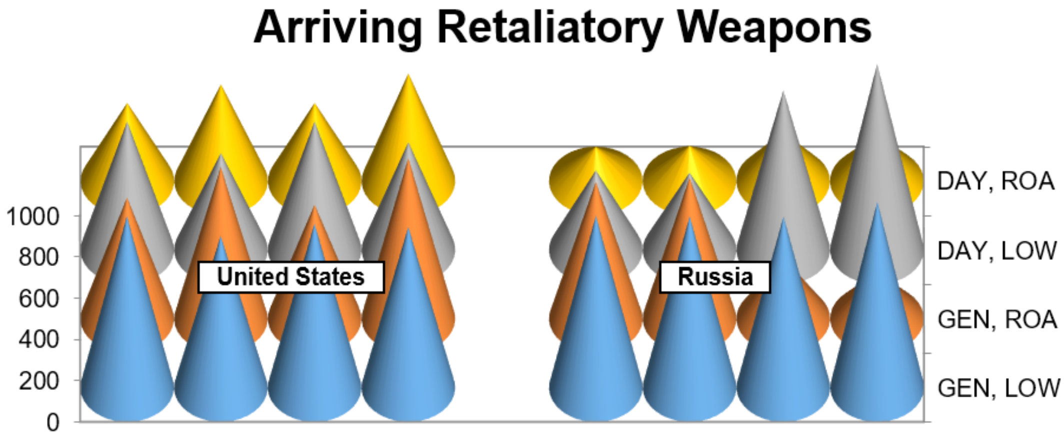
Although it will largely depend on who is in the White House and in the Kremlin, should the United States consider further reductions in nuclear forces, it is worth exploring the possible implications of those reductions. This is particularly important for the USAF as it looks to recapitalize its nuclear forces, which are the purview of New START. It may be worth noting that such a move, at present, is highly unlikely given President Trump's stated policy, Russia's aggressive actions in its near abroad, and the recent abrogation of the INF Treaty. However, examining the question is still worth contemplating. Thus, this begs the question; based on existing nuclear exchange models can the United States maintain strategic stability in a post–New START environment with smaller numbers of operationally deployed strategic nuclear weapons?

NEW START MINUS

Modest Reductions

Before moving forward, it is worth highlighting the difficulty of further bilateral reductions in the number of operationally deployed strategic nuclear weapons. With Russia's tactical nuclear arsenal estimated to exceed 2,000 weapons and growing, the United States has indicated that future nuclear arms control agreements should include tactical nuclear weapons—a low probability option in the wake of the United States' withdrawal from the INF Treaty.[11] This is a point of fundamental disagreement between Russia and the United States because Russia has publicly stated it will not negotiate the size of its tactical nuclear arsenal as part of a future strategic nuclear arms reduction.[12] President Putin has also indicated that absent the removal of American ballistic missile defenses from Europe, Russia will not discuss further arms reductions.[13] Given Russian economic, conventional (military), and demographic weaknesses, President Putin's reliance on a robust nuclear arsenal as the great equalizer is not an unreasonable position for a Russian president to take. When one also considers that an attack on the Russian homeland from the Baltic states could see NATO ground forces in St. Petersburg within a matter of days, it is unreasonable to dismiss the near-paranoia Russians have when it comes to a feared invasion from the West. Understanding these practical challenges, a new Russo-American nuclear arms reduction treaty may be untenable if it threatens to eliminate the nuclear capability Russian leadership feels is required to effectively deter or stop NATO aggression, however unlikely.

Two possibilities exist for future post–New START reductions in American and Russian strategic nuclear forces. One approach would be incremental. In this approach, each state would reduce its number of deployed long-range nuclear weapons to a maximum of 1,000 operationally deployed strategic nuclear weapons. Under the assumption that each state deploys a maximum of 1,000 weapons on less than 700 delivery vehicles, the outcomes for each in terms of second-strike surviving and retaliating weapons are summarized in Figure 2.



	Balanced Triad	No ICBMs	No Bombers	SLBMs Only		Balanced Triad	No Bombers	No SLBMs	ICBMs Only
GEN, LOW	830	735	795	778		833	829	828	900
GEN, ROA	587	735	552	778		663	684	293	226
DAY, LOW	622	469	622	521		385	373	772	900
DAY, ROA	379	469	379	521		165	170	238	226

Figure 2: U.S.-Russia Surviving and Retaliating Warheads 1,000 Deployment Limit

As might be expected, the numbers of surviving and retaliating weapons for the U.S. and Russia are smaller than they were in the previous case of 1,550 deployed weapons. This finding does not tell the entire story. It is also the case that some degrees of freedom in other areas are lost. The numbers of second-strike surviving and retaliating warheads for each state in the case of 1,000 prewar deployed weapons, compared to the 1,550 case, is more restrictive of flexible targeting options, of operational withholds for follow-on attacks, and for the retention of residual forces to support post-attack escalation control or war termination. Under some conditions, especially on day-to-day alert, either state might be challenged to fulfill the requirements of the assured retaliation mission promptly if unexpected technical glitches encumbered either the launch or command-control systems.

This is particularly important in a world where China is steadily growing the number and capability of its nuclear weapons and where North Korea is attempting to do the same.[14] No longer is deterrence a bilateral game. It is multilateral and requires the United States to credibly deter multiple adversaries.

The case of a deployment limit of 1,000 operationally deployed strategic nuclear weapons, a distinction that must be understood, presents a mixed situation. It does reduce the size of the first-strike threat facing each state, should political relations deteriorate and fears of nuclear attack ever become realistic, compared to the 1,550 case. On the other hand, it also reduces the numbers of surviving and retaliating weapons for each state that provides the backbone of deterrence based on assured retaliation. The 1,000 case is thus a trade-off: additional political reassurance and more damage limitation in wartime, compared to the 1,550-deployment limit; on the other hand, deterrence might be less secure, especially extended deterrence for allies against attack or coercion, and leaders would have fewer post-attack options with their remaining forces. The larger question for American policymakers is thus: are the added

	Balanced Triad	No ICBMs	No Bombers	SLBMs Only		Balanced Triad	No Bombers	No SLBMs	ICBMs Only
GEN, LOW	411	385	415	389		416	422	423	435
GEN, ROA	318	385	321	389		311	308	253	192
DAY, LOW	286	234	312	260		254	256	367	435
DAY, ROA	193	234	219	260		133	122	197	192

Figure 3: U.S.-Russia Surviving and Retaliating Warheads 500 Deployment Limit

uncertainties (proliferation among allies, first-strike incentive, reduced risk perception) that accompany further reductions worth the increased reduction in nuclear forces? The answer is speculative, making yes or no little more than an educated guess. There simply is no authoritative manner in which to answer this question.

Minimum Deterrence

A second post–New START strategic nuclear arms control regime might be more ambitious than the reductions to a deployed limit of 1,000 operationally deployed strategic nuclear weapons. Leaders might seek to reduce each of the peacetime numbers of operationally deployed weapons to several hundred instead of 1,000 weapons. Such a drastic step toward “minimum deterrence” would be welcomed by advocates of nuclear arms control, but how realistic would it be for American or Russian nuclear war planners or political leaders?[15] The assumption of strategic risk is significant and would offer little room for hedging against technical or strategic risk.

In this analysis, a maximum number of 500 operationally deployed long-range nuclear weapons is allocated to each state. The numbers of second-strike surviving and retaliating warheads for the U.S. and Russia are calculated and displayed in Figure 3.

The transition from an upper deployment limit of 1,000 to 500 deployed weapons is more significant than the step down from 1,550 to 1,000 warheads. In the smaller case of 500 deployed weapons, the assured retaliation mission can be accomplished but with little or no flexibility in targeting. Weapons will be allocated mostly, if not entirely, against cities and other economic and social assets (counter-value) in the hope that targeting large populations will cause sufficient risk aversion. Few if any surviving weapons will be available for attacks on opposing nuclear forces, conventional forces, military command centers, or other “counter-force” targets. The maintenance of a nuclear reserve force for post-attack bargaining, including escalation control and war termination, is all but impossible.[16]

To live within the constraints of a minimum deterrence deployment of 500 or fewer operationally deployed strategic nuclear weapons, Russia would have to fundamentally realign its current nuclear force structure and future modernization plans. At or below 500 weapons, silo-based intercontinental ballistic missiles (ICBMs) become serious liabilities because of their first-strike vulnerability compared to SLBMs or mobile ICBMs. Therefore, a Russian force downsized to 500 would have to relocate a larger proportion of its weapons on mobile land-based or sea-based missiles than it does now. Depending on the state of its economy and the competing priorities for modernizing its conventional military forces, Russia might be loath to abandon its ICBM-heavy strategic nuclear force structure, including some of its legacy silo-based ICBMs.

For the United States, a 500-warhead force would impose serious constraints on its ability to provide extended deterrence commitments for its non-nuclear allies in Europe and Asia. Allies like Japan and South Korea are already feeling threatened by nuclear armed regional neighbors. A move to minimum deterrence might lead these allies to take more seriously the option of developing and deploying their own nuclear forces.[17] In addition, in order to preserve its preeminence in ballistic missile firing submarines and long-range bombers, the United States might be forced to entirely eliminate the ICBM leg of the nuclear triad or reduce its size to the point of triviality.[18] What is perhaps most likely is that the United States would move to a sea-based monad. The challenge with this approach is that it allows Russia and China to focus their efforts on anti-submarine warfare (ASW). In such a scenario, the U.S. nuclear arsenal could conceivably be destroyed without the use of a single nuclear weapon. Unlike Russia, the United States does not have road- or rail-mobile ICBMs, which means it would likely depend solely on its sea leg.

Nuclear conflict would also certainly move to a focus on "city killing" rather than a focus on the destruction of military targets. For both Russia and the United States, there is an incentive to strike first. The logic is rather straightforward. At low numbers, the probability of maintaining a survivable second-strike capability is low. For the United States in particular, once a ballistic missile submarine launches even one of its SLBMs its position is known to the adversary. Thus, its ability to "shoot and scoot" is only limited by the ASW capability of the adversary.

Operating under a deployment limit of 500 weapons, Russia and the United States would also be challenged to maintain nuclear flexibility and resilience.[19] The options for equipping some portion of the nuclear retaliatory force with conventional warheads for prompt global strike missions would be restricted. So too might options for using nuclear weapons outside of a U.S.-Russia crisis be restricted, such as the employment of low-yield precision nuclear weapons against hardened storage bunkers. There is also the problem of missile defenses and its possible impact on the retaliatory deterrents of both the United States and Russia. Absent a complete ban on any type of missile defense, moving to 500 weapons would be untenable.[20]

An emerging challenge that is yet to be fully understood and is still speculative is the impact of new technologies (hypersonic weapons, robotics, artificially intelligent drones, and more) on minimum deterrence. Nuclear command, control, and communication (NC3) systems would also become an increasingly attractive target because a smaller nuclear arsenal may lead an adversary to believe that it is possible to destroy the United States' NC3 system prior to an attack on the nation's nuclear arsenal. Given the increasing threat cyber, hypersonics, and EMP attack pose to the NC3 system, the attractiveness of a pre-emptive first strike increases as the U.S. nuclear arsenal decreases.

While some will dismiss such a suggestion, it is important to avoid mirror imaging and attributing American values and interests to adversaries. Both China and Russia have proven that neither state values human life in the same way it is valued in the United States. The long and bloody history of both countries should give Americans reason to be concerned that minimum deterrence makes a preemptive first strike more attractive. Given that technological advancements are offering a more diverse array of weapons, that are difficult to defend against, a clear-eyed view toward arms control is certainly required.

Triads or Dyads?

The United States and Russia have both committed their governments to extensive nuclear modernization programs over the next two decades, including their strategic and tactical nuclear delivery systems and weapons.[21] Analysts and policymakers in Moscow and Washington believe that Russia and the United States will both continue to field three distinct types of intercontinental (strategic) nuclear delivery systems: land-based ICBMs, SLBMs, and long-range bombers. The New START agreement discussed earlier also assumes that deployments through 2021 will consist of a triad of ICBMs, SLBMs, and bomber-delivered weapons for each state. Based on data exchanges required by New START, the U.S. State Department reports that both Russia and the United States are in compliance with New START limitations.[22]

It is not inconceivable that both American and Russian nuclear modernization plans over the next two decades, ambitious as they are, may be restricted by domestic political conditions, including budgetary restraints. Russia's economy, as a result of U.S. and EU sanctions following its annexation of Crimea and proxy war in Ukraine, as well as lower oil prices since 2014, may demand some painful trade-offs between "guns and butter."[23] Even within prospective military budgets, some modernization of conventional and nuclear forces may have to be deferred temporarily or postponed indefinitely.

New technologies, like those previously discussed, may take higher precedent. For the United States, the sequestration that imposed mandatory across-the-board cuts on defense and non-defense spending during the Obama administration has now given way to Trump administration requests (and congressional approval) for additional defense spending and relaxed budget caps.[24] Although the Trump administration is committed to nuclear modernization as well as other ambitious goals, including a space force, no budgetary regime is without constraints on departmental expectations and priorities.[25] An additional uncertainty is that "reality," in the form of technological surprises or previously unperceived threats of various magnitudes, may confound the best predictions, fiscal or otherwise. On the other hand, given President Trump's public statements, and the Republicans' long preference for defense spending over welfare and entitlement spending, it is reasonable to suggest that some pressures on defense spending will go away.

Should the Russian economic outlook worsen or defense budgets decline, hard choices among nuclear modernization priorities may be a necessity. Either the United States or Russia might take a closer look at eliminating one or more components of their traditional strategic nuclear triads of missile and airborne launchers. Such a choice would serve as a justification to reduce the size nuclear arsenals—achieving the move to lower numbers and de-facto arms control.

Cost savings are, however, no consolation if they result in strategic instability. The assumption of past American and Soviet or Russian planners has been that the triad provides diversity in launch systems that complicate an attacker's targeting. In addition, each leg of the triad has unique attributes. For example, in the American case, ICBMs are on alert and can be launched against the most time urgent targets. Bombers, on the other hand, can be used to signal intent and resolve during crises without irrevocable commitment to mass destruction. SLBMs are the most survivable component of the U.S. strategic nuclear triad.[26]

The challenge of eliminating a leg of the triad or further arms reductions is becoming more apparent as the implications of hypersonics, cyber-attack, robotics, and developing threats challenge the United States' confidence in its ability to ensure a credible second strike. Accounting for these new and developing threats is far more difficult than the model we employ for traditional nuclear forces. There simply is no way at the present time to offer predictions, of any sort, for remaining nuclear force after a hypersonic attack, for example. Thus, diversity of systems may be key to providing that certainty.[27] With the abrogation of the INF Treaty, the United States and Russia are likely to deploy intermediate-range nuclear weapons that will also pressure modernization budgets. Russia is already employing such weapons and the United States is testing the delivery systems.[28]

In the U.S. case (and doubtless for Russia as well), domestic priorities and bureaucratic politics play an important part in determining nuclear force structures. With neither the U.S.AF nor the USN eager to surrender the roles and missions assigned to them and both the Air Force and Navy capable of advocating for the uniqueness of their platforms, eliminating one leg of the triad is unlikely. For reasons of Soviet legacy and now Russian commitment, Russia's ICBMs are the makeweights of its nuclear deterrent. Russia's SLBM and heavy bomber forces have not been modernized as consistently or effectively as have strategic land-based missiles; this is, however, changing with the new Bulava class Ship, Submersible, Ballistic, Nuclear (SSBN).[29] Present declaratory policy for both the United States and Russia is that each state will retain a strategic nuclear triad, even if force sizes are reduced below New START levels in a future administration.

While the American and Russian nuclear triads have the force of history, strategy, and domestic politics behind them, this may change in the United States if President Trump looses the 2020 election to a candidate with strong arms control views and a congressional majority that also supports unilateral reductions. Such an unexpected event could make our analysis more relevant than anticipated. Fiscal constraints that result from an economic downturn or the reprioritization of federal funding toward domestic priorities may also prompt another look by the United States at the future of nuclear modernization. In light of the United States' dramatic growth in the national debt during the Trump administration, funding may also decline as it becomes imperative to reduce or reprioritize spending.[30]

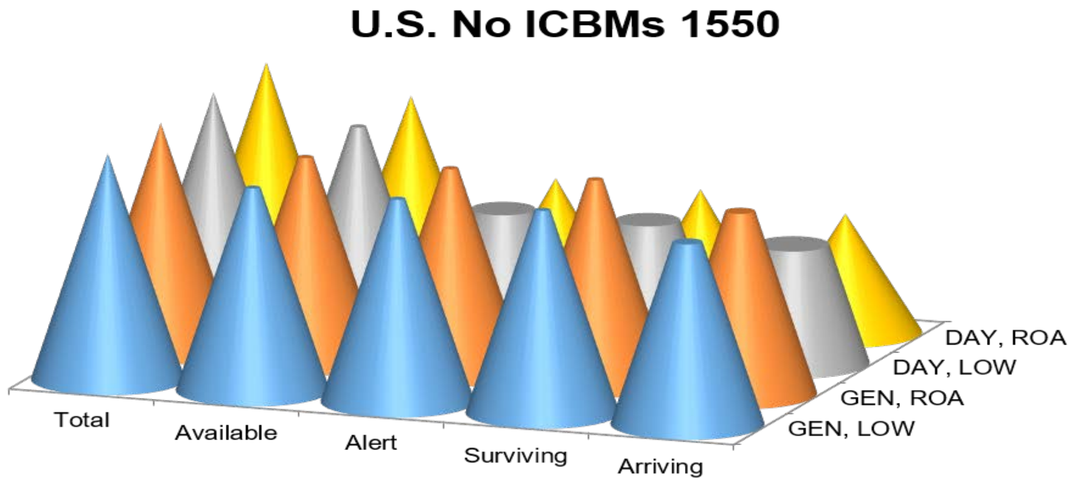
If either the United States or Russia decided to retire a leg of the triad, what would it be? Russia would probably retire the bomber leg of its strategic nuclear forces, relying on ICBMs and SLBMs for promptness and survivability. The United States, on the other hand, would probably preserve the SSBN-SLBM fleet and bomber forces and forego purchasing the Ground Based Strategic Deterrent (GBSD) to replace the Minuteman III. However, GBSD is already under way, making cancellation unlikely. The United States might also "conventionalize" its ICBMs by deploying them with non-nuclear warheads as the basis of its intercontinental Conventional Prompt Global Strike capability.[31]

Apart from costs, what does analysis show about the effectiveness of possible U.S. or Russian dyads compared to triads? Figure 4 summarizes the numbers of American surviving and retaliating weapons under the assumption of a U.S. strategic nuclear "dyad" without ICBMs, assuming a maximum deployment limit of 1,550 warheads. In this scenario, Russia maintains a triad of land- and sea-based missiles and bombers. Figure 5 then summarizes, under the same deployment limit, the number of surviving and retaliating warheads for each state, under the assumption of a Russian strategic nuclear "dyad" without heavy bombers. In this scenario, the U.S. maintains a triad of ICBMs, SLBMs, and bombers.

The results summarized in Figures 4 and 5 show that, at least in theory, the United States or Russia could fulfill requirements for assured retaliation by deploying dyads instead of triads compliant with New START limits on deployed warheads and launchers. Again, it is important to keep in mind that this analysis does not account for the employment of hypersonic weapons or any of the new technologies that we see fundamentally reshaping nuclear strategy in the years ahead.

According to our analysis, there is one asymmetry in comparing U.S. and Russian dyads that is worth noting. In giving up their dismal bomber force, Russia is not making nearly as much of a sacrifice as is the United States by mothballing its ICBM force. U.S. Minuteman III ICBMs are on track to be replaced by a far more capable Ground Based Strategic Deterrent. ICBMs deployed across multiple states in the continental United States create a prompt target set of more than 400 discreet targets that exhaust many more Russian warheads then do submarines and bombers, which can be destroyed solely with conventional weapons—leaving Russian nuclear weapons to strike U.S. cities and other targets. For example, a Russian two-on-one attack against 400 Minuteman III ICBMs plus their command centers would require first-strike commitment of about 800–900 warheads on intercontinental launchers. Under a New START cap of 1,550 deployed weapons, elimination of the U.S. ICBM force in a nuclear first strike would leave Russia with a residual force (compared to survivable U.S. forces) that is inadequate for intra-war deterrence or bargaining for war termination.[32] In effect, Russia virtually disarms itself even before two legs of the U.S. triad are fully employed.[33] In addition, the on-alert posture and launch on warning capability of U.S. ICBMs poses special demands on the decision-making process of an attacker. Hunter Hustus, a former advisor to the U.S. Air Force on strategic deterrence and nuclear weapons issues, has argued,

> The current on-alert posture (for ICBMs) increases presidential decision time, eliminates potential adversary misperceptions, and forces adversaries to think "slow" and



	Total	Available	Alert	Surviving	Arriving
GEN, LOW	1488	1339	1339	1339	1201
GEN, ROA	1488	1339	1339	1339	1201
DAY, LOW	1488	1339	868	868	781
DAY, ROA	1488	1339	868	868	781

Figure 4: U.S.-Russia U.S. Surviving and Retaliating Warheads U.S. Dyad (No ICBMs) 1,550 Deployment Limit

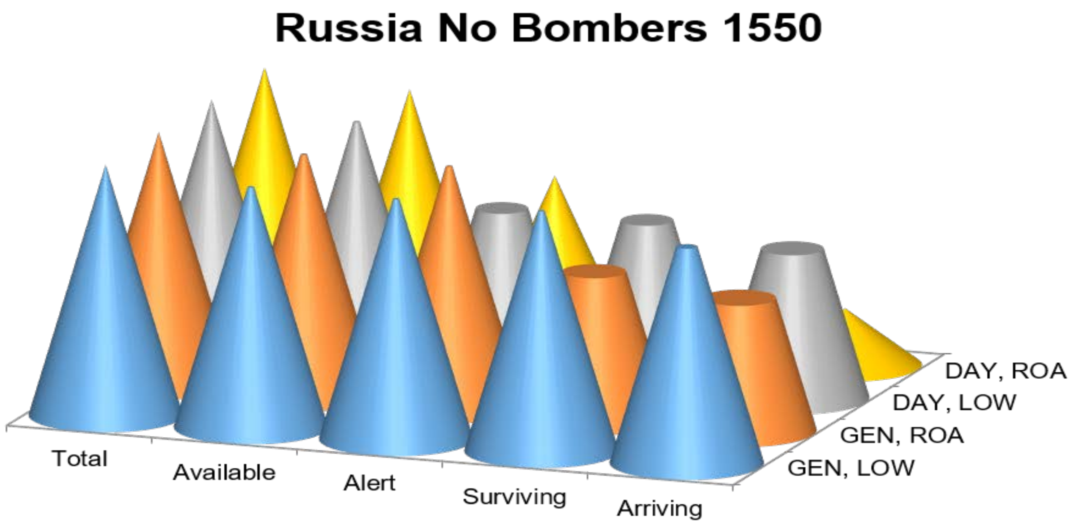
not "fast." It injects ambiguity into their decision making processes and denies any opportunity of profitable first strike.[34]

The case for maintaining a U.S. nuclear-strategic triad is therefore a strong one on the grounds of deterrence theory and as a hedge against "Murphy's law," but not necessarily unassailable on the basis of cost or arms control priorities. Much depends on which way technology takes future aircraft and missiles. For example, future hypersonic boost-glide systems for conventional prompt global strike might enable a strategic conventional option for urgent attack on a variety of targets—including nuclear forces and command-control systems.[35] Whether mature conventional precision-guided systems will reinforce deterrence, or contribute to crisis instability, remains to be determined. For Russia at least, conventional prompt global strike is a worrisome capability that is viewed as threatening the credibility of their nuclear forces.

Estimation of nuclear modernization costs can be challenging and is far from an exact science. Research and development for nuclear and other weapons systems involves trade-offs among weapons capabilities, responsiveness, mission appropriateness, and the price tag itself. In the case of U.S. nuclear modernization, more recent numbers suggest modernization will cost $494 billion through 2028.[36] This price tag has increased slightly over the past few years, but when compared to the larger federal budget, which is approximately $4.7 trillion for 2019 alone, nuclear modernization is a drop in the bucket.[37] The bigger challenge for planning nuclear modernization costs is posed by the new weapons that may challenge both nuclear forces and the NC3 system that commands and controls them.

CONCLUSION

Nuclear modernization and strategic nuclear arms control are often seen as at odds with one



	Total	Available	Alert	Surviving	Arriving
GEN, LOW	1547	1483	1483	1483	1335
GEN, ROA	1547	1483	1483	907	816
DAY, LOW	1547	1483	1022	1022	920
DAY, ROA	1547	1483	1022	389	350

Figure 5: U.S.-Russia Russia Surviving and Retaliating Warheads Russia Dyad (No Bombers) 1,550 Deployment Limit

another. U.S. and Russian willingness to limit the sizes and capabilities of their own nuclear arsenals does not guarantee that they will succeed in leading international security management on nonproliferation. In fact, the sizes of Russian and American nuclear arsenals are rarely the cause driving other states to contemplate or acquire nuclear weapons.[38] If Russia and the United States do not take a leading role in promoting nuclear nonproliferation by creating the conditions necessary to assure allies—in the case of the United States—or deter potential adversaries from viewing nuclear weapons as a viable security guarantor (North Korea and Iran), a new age of nuclear proliferation may be fast approaching. It is undoubtedly in the interests of both states to keep nuclear weapons and materials out of the hands of irresponsible regimes or terrorists. A modern and capable nuclear arsenal may be the best way to deter the aspirations of some and assure the fears of others.

On the other hand, discussion of Russo-American bilateral strategic nuclear arms reductions must take into consideration the larger impacts on geostrategic stability that are all too often left undiscussed by the advocates of such agreements. In that respect, reductions in the numbers of American and Russian operationally deployed strategic nuclear weapons below the New START maximum of 1,550 warheads on 700 launchers are likely to be a net loss for strategic stability. Analysis suggests that reductions to 1,000 or 500 deployed weapons would leave policymakers and military planners in Washington and Moscow without the nuclear flexibility and resilience they require for their assigned missions and for unforeseen “Black Swan” circumstances. More ambitious reductions to a minimum deterrent of several hundred weapons could reduce nuclear flexibility to levels that are dramatically unstable and increase the risk tolerance of a leader like Vladimir Putin who seeks to change the status quo.[39]

Beyond the numbers is the larger issue of whether nuclear arms control, as between the United States and Russia, or within more ambitious multilateral forums, is a dead letter. The U.S. and Russia have scrapped the Intermediate Nuclear Forces (INF) Treaty, leaving New START as the remaining pivot for nuclear arms control negotiations. Some fear the obsolescence of arms control and the renewal of a new arms race between the United States and Russia.[40] As arms control expert and experienced negotiator Rose Gottemoeller has noted:

> The most basic aim of arms control regimes is to create mutual predictability, ensuring that no country participating is uncertain about its security both now and into the future. In this way, arms control helps to keep defense spending in check, but it also allows countries to build up mutual confidence and stability, which can translate into broader security and economic ties.[41]

Others are concerned that the risks of nuclear war are rising between the United States and Russia as a result of political differences that could explode into European limited wars or separatist conflicts with the potential for nuclear escalation. New technologies are also possible initiators of nuclear conflict: as George Beebe has noted, cyber technologies, artificial intelligence, advanced hypersonic systems and anti-satellite (ASAT) weapons "are blurring traditional lines between espionage and warfare, entangling nuclear and conventional weaponry, and erasing old distinctions between offensive and defensive operations."[42] Therefore, beyond the prudence required to identify the line between necessary and superfluous new weapons, there is also the need to prioritize modernizations that can coexist with, and not unintentionally destabilize, whatever remains of the nuclear arms control regime. As Clausewitz might have thought, modernization and arms control have their own grammar, but not their own logics.

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1. For a look at the most relevant recent research on nuclear modernization and strategic deterrence see: Bruce G. Blair, "Loose Cannons: The President and U.S. Nuclear Posture," *Bulletin of the Atomic Scientists*, 76, no. 1 (2020), 14-26: Adam B. Lowther and Stephen J. Cimbala, eds. *Defending the Arsenal: Why America's Nuclear Modernization Still Matters* (London: Routledge, 2017); Brad Roberts, *The Case for Nuclear Weapons in the 21st Century* (Stanford: Stanford University Press, 2016); Andrew Futter, *The Politics of Nuclear Weapons* (London: Sage Publications, 2015); Kier Lieber and Daryl G. Press, "The New Era of Nuclear Weapons, Deterrence, and Conflict," *Strategic Studies Quarterly*, no. 1 (Spring, 2013); Paul Bracken, *The Second Nuclear Age: Strategy, Danger, and the New Power Politics* (New York: Henry Holt, 2012); Adam B. Lowther, ed., *Deterrence: Rising Powers, Rogue Regimes, and Terrorism in the Twenty-First Century* (New York: Palgrave-Macmillan, 2012); Michael Krepon, *Better Safe than Sorry: The Ironies of Living with the Bomb* (Stanford: Stanford University Press, 2009); Lawrence Freedman, *Deterrence* (Cambridge: Polity Press, 2004); Patrick M. Morgan, *Deterrence Now* (Cambridge: Cambridge University Press, 2003); Keith B. Payne, *The Fallacies of Cold War Deterrence and a New Direction* (Lexington: University Press of Kentucky, 2001); Colin S. Gray, *The Second Nuclear Age* (Boulder: Lynne Rienner, 1999); Bruce G. Blair, *The Logic of Accidental Nuclear War* (Washington, DC: Brookings Institution, 1993); and Robert Jervis, *The Illogic of American Nuclear Strategy* (Ithaca, N.Y: Cornell University Press, 1984).

2. See Todd Harrison and Evan Montgomery, *The Cost of U.S. Nuclear Forces: From BCA to Bow Wave and Beyond* (Washington, DC: Center for Strategic and Budgetary Analysis, 2015).

3. Kingston Reif, "As INF Treaty Falls, New START Teeters," *Arms Control Today* (March 2019), 1–5.

4. Mark V. Arena, John C. Graser, and Paul DeLuca, *Implications of an Air Force Budget Downturn on the Aircraft Industrial Base: An Exploratory Analysis* (Santa Monica: RAND Corporation, 2013); Carlin Leslie, "AF Budget Director Outlines Challenges, Opportunities to AFA Members," *Air Force Public Affairs Agency* (March 12, 2014).

5. Jeremiah Gertler, *The Air Force Aviation Investment Challenge* (Washington, DC: Congressional Research Service, 2015).

6. Adam Lowther and Curtis McGiffin, "America Needs a 'Dead Hand,'" *War on the Rocks* (August 16, 2019).

7. *Treaty between the United States of America and the Russian Federation on Measures for the Further Reduction and Limitation of Strategic Offensive Arms* (Washington, DC: Department of State, 2010).

8. See Amy F. Woolf, *U.S. Strategic Nuclear Forces: Background, Developments and Issues* (Washington, DC: Congressional Research Service, March 18, 2015), 8; Hans M. Kristensen, *Trimming Nuclear Excess: Options for Further Reductions of U.S. and Russian Nuclear Forces* (Washington, DC: Federation of American Scientists, December 2012); James Cartwright, *Report: Modernizing U.S. Nuclear Strategy, Force Structure and Posture* (Washington, DC: Global Zero, May 2012); and Pavel Podvig, "New START Treaty in numbers," *Russian Strategic Nuclear Forces*, 2010. See also Joseph Cirincione, "Strategic Turn: New U.S. and Russian Views on Nuclear Weapons," *New America Foundation*, (2011) and Arms Control Association, *U.S. Strategic Nuclear Forces Under New START* (Washington, DC: Arms Control Association, 2011).

9. Grateful acknowledgment is made to James Scouras for use of his Arriving Weapons Sensitivity Model (AWSM) in making calculations and drawing graphs. Additional information about the model is available in Stephen J. Cimbala and James Scouras, *A New Nuclear Century* (Westport, Ct.: Praeger Publishers, 2002).

10. See Carl von Clausewitz, *On War*, translated by Michael Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1989), 101–108; and Nassim Nicholas Talib, *The Black Swan* (New York: Random House, 2010).

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12. Amy F. Woolf, *Nonstrategic Nuclear Weapons* (Washington, DC: Congressional Research Service, 2016), 24–35.

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15. Arguments in favor of minimum deterrence appear in James Wood Forsyth Jr., B. Chance Saltzman, and Gary Schaub Jr., "Minimum Deterrence and Its Critics," *Strategic Studies Quarterly*, no. 4 (Winter 2010), 3–12, and in Forsyth, Saltzman, and Schaub, "Remembrance of Things Past: The Enduring Value of Nuclear Weapons," *Strategic Studies Quarterly*, no. 1 (Spring, 2010), 74–89. See also Bruce Blair, Victor Esin, Matthew McKinzie, Valery Yarynich, and Pavel Zolotarev, "One Hundred Nuclear Wars: Stable Deterrence between the United States and Russia at Reduced Nuclear Force Levels Off Alert in the Presence of Limited Missile Defenses," *Science and Global Security,* 19

(2011), 167–194.

16. In Herman Kahn's *On Escalation: Metaphors and Scenarios*, a detailed discussion of how escalation and de-escalation might occur and the rungs of such an "escalation ladder" are described, along with the events that might cause a move up or down the escalation ladder.

17. For example, see Doug Bandow, "Maybe U.S. Should Defend South Korea by Letting it Develop Nuclear Weapons," *Cato at Liberty* (August 11, 2014).

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21. For the U.S., see U.S. Congressional Budget Office, *Approaches for Managing the Costs of U.S. Nuclear Forces, 2017 to 2046* (Washington, D.C.: Congressional Budget Office, October 2017). See also: Congressional Budget Office, *Projected Costs of U.S. Nuclear Forces: 2015 to 2024* (Washington, DC: Congressional Budget Office, January 2015) and John B. Wolfsthal, Jeffrey Lewis, and Marc Quint, *The Trillion Dollar Nuclear Triad: U.S. Strategic Nuclear Modernization Over the Next Thirty Years* (Monterey, CA: James Martin Center for Nonproliferation Studies, January 2014). For Russian nuclear modernization, see Mark B. Schneider, *The Nuclear Forces and Doctrines of the Russian Federation and the People's Republic of China* (Washington, DC: Prepared Testimony, U.S. House of Representatives, House Armed Services Subcommittee on Strategic Forces, October 14, 2011); Mark B. Schneider, *Russian Nuclear Modernization* (Fairfax, VA: National Institute for Public Policy, June 20, 2012) and Pavel Podvig, "New START Treaty in numbers," *Russian Strategic Nuclear Forces* (April 9, 2010).

22. Frank Rose, *The End of an Era? The INF Treaty, New START, and the Future of Strategic Stability* (Washington, DC: Brookings Institution, 2019).

23. World Bank, *Russia Overview* (Washington, DC: World Bank, 2016).

24. U.S. Department of Defense, *Fiscal Year 2020 Budget Request* (Washington, DC: Office of the Under Secretary of Defense, 2019).

25. Authoritative estimates appear in U.S. Congressional Budget Office, *Approaches for Managing the Costs of U.S. Nuclear Forces, 2017 to 2046* (Washington, DC: Congressional Budget Office, October 2017) also, for additional perspective on the U.S. budgetary picture as it might affect nuclear force modernization: Michaela Dodge and Adam B. Lowther, "Nuclear Budgeting: The Perilous Impact of Uncertainty," in Adam Lowther and Stephen Cimbala, eds., *Defending the Arsenal: Why America's Nuclear Modernization Still Matters* (London: Routledge, 2016).

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32. James E. Dornan Jr. et. al., *War Termination Concepts and Political, Economic, and Military Targeting* (Washington, DC: Defense Advanced Research Projects Agency, 1978), 6-12.
33. And doubtless some of the U.S. ICBM force would also escape destruction by being launched on warning or under attack, although neither is official U.S. policy.
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37. Kimberly Amadeo, "U.S. Federal Budget Breakdown," *The Balance* (June 25, 2019).
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39. Russia's 2014 Military Doctrine, publicly endorsed by President Vladimir Putin in December 2014, suggests increasing interest in a "system of nonnuclear deterrence—a complex of foreign-policy, military and military-technical measures aimed at preventing aggression against the Russian Federation by non-nuclear means." See Roger McDermott, "Putin Signs New Military Doctrine: Core Elements Unchanged," *Jamestown Foundation Eurasia Daily Monitor* (2015). See also ITAR-TASS, "Putin endorses updated version of Russia's military doctrine" (December 26, 2014).
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Why Can't We Be Friends?: An Assessment of U.S.-Russia Relations and Deterrence

MAJ Whitney L. Cissell and Dr. Wade Huntley
Naval Postgraduate School

> Putin's Russia is an adversary of the United States; the Kremlin needs to have an external enemy to distract the Russian people from the problems plaguing their country.
> —Alina Polyakova[1]

The *2018 United States National Security Strategy* designates China and Russia as principal priorities, and the *2018 National Military Strategy* places a new emphasis on diffusion and competition, shifting priorities away from counterterrorism and onto great power competition. These strategic shifts demand an examination of the way the United States and Russia interact in competition to achieve their political aims and how that relationship influences both states' policy, strategy, and deterrence.[2]

United States-Russia Relations

The end of the Cold War brought about a sense of hope for peace between nations; however, the relationship between the United States and Russia has systematically declined from optimism to distrust and landed squarely in adversarial territory. Russia's distrust and resentment reflect its perception that much Western behavior, such as the North Atlantic Treaty Organization (NATO)'s enlargement, deliberately intends to impinge Russia's legitimate interests. Russia often cites the actions of the United States and NATO—and the enlargement of NATO throughout history—as the main components of its antipathy and distrust of the West. Most scholarly analysis concludes that this is only one dimension of the contentious relationship. Russia's rejection of Western diplomatic

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overtures is also driven by its overinflated sense of global importance, historical entitlement to territorial and influential expansion, and its need to inflate external threats to secure domestic support for the regime. While NATO enlargement and Western actions may be an antagonistic factor, it is unclear what roles different factors play in driving Russian attitudes and behavior.

However, if we want to understand how the U.S.-Russia relationship effects deterrence, it is imperative to recognize the Russian perspective. An analysis of key historical events can offer insight into how Russia could perceive and react to potential U.S. deterrent strategies.

Steady Deterioration

After the fall of the Soviet Union, the United States, in partnership with its European allies, structured the European security environment with relatively little input from a weakened Russia, which had few remaining allies and faced an economic crisis as a result of the former Soviet Union's unstainable overreach and unproductive economy. The new environment gave independence to formerly oppressed Soviet Union states, ousted communist regimes across Europe with free elections, and left Russia with the loss of territory and a complex list of motivations toward its present desire for expansion.

During this time, the United States and its European allies extended diplomacy to Russia in the interest of security cooperation and peace between nations. From 1993 to 2001, President Bill Clinton cultivated a relationship with Russian President Boris Yeltsin and sought to integrate Russia into international institutions. At the 1994 NATO summit in Brussels, a U.S. initiative, the Partnership for Peace, was established. The program was designed to create trust between European and former Soviet Union states; it currently has 21 members.[3] President Clinton stated that the program was a "track that [would] lead to NATO membership" and highlighted that it did not "draw another line dividing Europe a few hundred miles to the east."[4] Additionally, suffering a massive economic burden in 1997, Russia was added to the G7, which then became the G8.[5] The addition of Russia was meant to forward diplomatic relations and security cooperation between the states. Diplomatic efforts toward Russia continued in 1997 with the NATO Russian Founding Act, which intended "to overcome the vestiges of past confrontation and competition and to strengthen mutual trust and cooperation."[6] The act also established a joint council between NATO and Russia, which attempted to strengthen diplomatic relations between Europe, the United States, and Russia even further.

Diplomatic efforts toward cooperation were undercut, however, by opposing U.S. policies, such as continued NATO enlargement, that engendered Russian opposition.[7] From March to June 1999, U.S.-Russian relations were dealt a devastating blow amidst NATO operations in Kosovo, which were undertaken without a UN Security Council resolution and against stark Russian objections. This operation proved to be key in shaping Russia's threat perception and worldview.[8] Such a perception was anticipated by Henry Kissinger in 1999 when he warned, "The transformation of the NATO alliance from a defensive military grouping to an institution prepared to impose its values by force undercut repeated American and allied assurances that Russia had nothing to fear from NATO expansion."[9] The bombing campaign marked the first time NATO had utilized military force without the authorization of the UN Security Council. President Vladimir Putin has repeatedly called the bombing a turning point in U.S.-Russian relations and linked it to NATO's eastward expansion.[10]

In 2008, Russia continued to pursue its strategic goal of expansion, halting the enlargement of NATO by invading Georgia, a former Soviet bloc state with previous aspirations of joining NATO. Tensions between Russia and Georgia escalated after the latter transitioned to a pro-Western regime and continued to rise in severity. The hostilities culminated in Russia's violating the sovereign territory of Georgia by launching a ground attack, information warfare campaign, naval blockade of the Georgian coast, and an air bombing campaign.[11] In response to the invasion, NATO suspended all formal meetings of the NATO-Russian council as well as cooperation in other areas.[12] The invasion of a sovereign state, coupled with humanitarian atrocities, signaled the end of positive diplomatic relations and an era marked by Russia's adversarial view of the West.

Skeptical of the West, President Putin, with his background as a KGB officer, has repeatedly professed his belief that the United States attempted to interfere in an already contentious period in Russian politics through inciting mass protests in Moscow from 2011 to 2012. The protests came on the heels of a wave of toppled autocratic governments during the Arab Spring, which started in 2010.[13] President Putin voiced concern that the United States had a hand in the Arab Spring uprising and had been trying to subjugate Russia by sowing unrest in the Russian population through stoking protests against him.[14] This incorrect belief that the United States was involved only stood to further the distrust and adversarial relationship with the West. Dr. Brad Roberts explains that during his time in the Obama Administration, it was clear "President Putin [had] concluded that there was a fundamental conflict of interest with the United States, that it was a zero-sum game. The US was pursuing interests against Russia that were simply unacceptable to President Putin and as such, he reconceived a relationship of enduring conflict."[15]

The need for Russia to arrest the expansion of Western influence, in combination with its desire to expand its own influence into the former Soviet bloc states, ultimately led to one of the most punctuating events in U.S.-Russian relations, causing a dramatic increase in antagonism between the states. In 2014, Russia invaded Ukraine and annexed the Crimean Peninsula, violating the signed NATO-Russia Founding Act, which pledged to uphold "respect for sovereignty, independence and territorial integrity of all states and their inherent right to choose the means to ensure their security."[16] The annexation came on the heels of a failed attempt by Russia to disrupt the growing relationship between Ukraine and the West by preventing Ukraine from signing the Ukraine–European Union Association Agreement. Russia pressured the Ukrainian leadership, through trade obstruction and leverage as a prominent trade partner, to sign an alternative agreement with the Customs Union of Russia, Belarus, and Kazakhstan, which Ukraine's government under pro-Russian President Yanukovych did.[17] Russia's victory was short-lived as the move sparked outrage among the Ukrainian domestic base, which wanted to turn toward the West through the European Union (EU) agreement. The dissatisfaction led to a revolt, including violent confrontations and casualties, ending in the ousting of President Yanukovych, who remains in exile in Russia today.[18]

The annexation of Crimea was economically and diplomatically costly to Russia—and to the relationship between Russia, the United States, and NATO. The United States and Europe responded to the invasion by imposing stringent economic sanctions on Russian businesses and oligarchs, providing military and financial support to Ukraine, and publicly condemning Russian actions.[19] In addition, the G8 suspended Russia. The EU discontinued regular bilateral summits with Russia, suspended the dialogue on visa issues and a new bilateral agreement, and imposed gradual sanctions on Russia.[20] Additionally, after the downing of flight MH17 on June 17, 2015, over territory controlled by Russian-supported rebels in eastern Ukraine, the EU significantly expanded its sanctions and stopped Russian accession to the Organization for Economic Co-operation and Development and the International Energy Agency.[21]

However, the Ukraine incursion might still be perceived by Russia as a victory. Chapter one of the NATO membership action plan states that "aspirant nations must be able to settle ethnic disputes or external territorial disputes, including irredentist claims or internal jurisdictional disputes, by peaceful means in accordance with Organization for Security and Co-operation in Europe principles, and to pursue good neighborly relations."[22] By fomenting a territorial conflict, Russia effectively denied Ukraine NATO membership candidacy.[23] Additionally, the events of Crimea and the diplomatic aftermath that followed play well into the Russian narrative that the West is an enemy of the Kremlin. However, the events are also damaging to Russia's image as a great power in the international community, which Russia is concerned with and something the United States can use in its effort to deter these types of actions in the future.

Just two years later, in 2016, Russia attempted to interfere in the U.S. presidential election by gaining access to the Democratic National Committee, leaking its documents to the media,[24] and executing an information operations influence campaign to sway American voters.[25] The interference was a milestone in U.S.-Russian relations as it highlights the lengths to which Russia will go to expand its influence over the West and assert itself as a great power able to rival the capabilities and will of the West.

<u>Arms Control</u>

Despite being a consistent priority in U.S.-Russian relations since the 1960s, nuclear arms agreements have begun to disintegrate, with the potential for more to fall apart in the future. In October 2018, after a summit between the United States and Russia attempting to save the Intermediate-Range Nuclear Forces (INF) Treaty failed, the United States declared its intention to pull out of the treaty. The 1988 INF Treaty had been a landmark achievement and had prompted cooperation toward the end of the Cold War.[26] Another U.S.-Russian arms control treaty, the New Strategic Arms Reduction Treaty, will expire in February 2021, although it can be extended for another five years with mutual agreement by the two parties. If it expires, it will constitute the end of the last major arms control agreement between the United States and Russia and a transition to an uncertain new period in U.S.-Russian relations without restrictions on strategic weapons.[27]

Russian Strategic Assessment

Many analysts assess Russia as an opportunistic revisionist state in slow decline with adversarial views of the West including the United States and NATO.[28] Some view Russia as eager to be seen as a great power on the international stage with a desire to be consulted—and even deferred to—for issues in its geographical region. In this view, Russia's main strategic objectives include regime survival; geopolitical dominance, including recognition as a great power; a renegotiation of the European security order; and the weakening of the West, including U.S. influence and the cohesion of the NATO alliance. Russia's opportunistic revisionism means that it is expansionist but not to the point that it will attempt territorial expansion, which Russian leaders believe will incite a powerful response from either the United States or NATO. In the immediate abroad, Russia is amenable to Georgia, Ukraine, Azerbaijan, and Moldova's staying outside of Russian control if they remain out of NATO and also "remain neutral in terms of security arrangements."[29]

Russia is sometimes seen as risk-averse to open conflict with the United States and NATO yet risk-acceptant to lower levels of conflict, such as action in the gray zone, if it forwards Russia's national objectives.[30] Eugene Rumer and Richard Sokolsky effectively summarize this position: "Russian leaders see their country as a great power in charge of its destiny. They do not accept American primacy and want to accelerate the transition from a unipolar to a multipolar world; they believe they are entitled to a sphere of influence and will resist perceived U.S. intrusions."[31]

Russia is a powerful state, yet it is in steady decline with vulnerabilities in its political structure; a declining oil-based economy; poor international standing; limited allies (only Kazakhstan and Belarus); and a population frustrated with the lack of rule of law, quality of life, political voice, and limited disposable income. Douglas Lute states that Russia is "weak economically, weak internationally, and has no conventional measure of state power to assess that they are doing well."[32]

Russia expresses the view that the international environment and future world development are competitive, under tension, in rivalry over values, politically and economically unstable, and generally complicated in all foreign relations.[33] This view becomes the lens through which Russia evaluates its threats and weighs heavily on the prospect for future cooperation, diplomatic strategies, and deterrence. Russia also recognizes that the changing character of conflict includes the utilization of sub-conventional means and "integrated employment of military force and political, economic, informational or other non-military measures implemented with wide use of the protest potential of the population and of special operations forces."[34] Russia's perception of the international environment as competitive and hostile, its desire for revision, and its position of relative weakness combine to drive it to the increased use of sub-conventional warfare and gray zone strategies.[35]

Russia uses a gray zone strategy of non-military means, such as information campaigns directed at ethnic Russian populations in "near-abroad" states and at Western populations, in an attempt to sow discord and gain influence. Russia also utilizes the information domain to solidify the support of its domestic base through camaraderie over a common enemy in the West.

Russia's Gray Zone

Russia's use of the gray zone aims to gain leverage against the United States and NATO and forwards its national objectives while avoiding a powerful U.S. or NATO response. Russia's gray zone activities include a wide variety of tactics;

however, many of them relate to the information space, including influencing ethnic Russian populations, waging disinformation campaigns, meddling in elections, and sabotaging economies.

Russia seeks to influence ethnic Russian populations, who the Russian government describes as *sootechestvenniki*, or "compatriots."[36] Vera Zakem, Paul Saunders, and Daniel Antoun explain that "Russia's government defines the term compatriots broadly to incorporate not only ethnic Russians and Russian speakers, but also their families as well as others who may have cultural or other connections to the Russian Federation—including its non-Russian ethnic groups—directly or through relatives."[37] Russia has mobilized these groups in a variety of countries in its near-abroad including Ukraine, Estonia, and Georgia.[38] Russia uses a compatriot influence strategy to further its larger political goals and leverage information operations. Disinformation strategies, economic relationships, corruption, and the Russian Orthodox Church are critical assets in influencing and molding compatriots.[39]

The existence of Russian ethnic populations in other states gives strength and legitimacy to Russia's claim to a great power status by showing that its world and influence expand past territorial borders. Russian compatriots also act as an amplifying force to Russia's political influence in its near abroad by aligning with Russian culture and ideals. Russia can also use its compatriots to sow unrest in their host state governments, such as when Russia supported eastern Ukrainian separatists. Russia also uses its compatriots as a rallying point for its domestic and international audience by asserting that it must provide protection for the Russian people wherever they may live. Lastly, Russia can use its compatriots to provide military, political, and economic intelligence and situational awareness.

Russia's ability to generate extensive information campaigns designed to spread *dezinformatsiya*, or disinformation, is supported by the "Russian state media, such as Russia Today (RT) and Sputnik; private media in Russia and other countries; social media, and cyber-attacks."[40] A few examples of Russia's tactics include using social media to gain influence in Eastern Europe, disseminating propaganda to sway compatriots in its near abroad, waging cyber campaigns against its adversaries, and spreading disinformation to sow dissent against host and neighboring governments, NATO, and the EU.

A report on Russia's use of non-military means from the RAND Corporation details how, since the late 2000s, Russia has focused on propaganda and disinformation efforts, such as "cyberattacks on Estonian banks, government entities, and media outlets," and with the invasion of Georgia in 2008, it disseminated "multiple narratives online, providing alternative explanations for its actions."[41] After the annexation of Crimea, through "the wide presence of Russia in Ukrainian media space and popularity of Russian social networks, Russia was able to actively use social media to mobilize support, spread disinformation and hatred, and try to destabilize the situation in Ukraine."[42] Other tactics used since the annexation of Crimea include direct messaging to Ukrainian soldiers' cell phones.[43] These operations are supported by an extensive disinformation campaign that clouds the facts on the ground and creates ambiguity about Russia's intentions.

Russia often employs multiple disparate gray zone tactics that complement each other and provide a greater chance of a successful outcome. Some examples include using non-military means, such as trojan malware that automatically drives traffic to pro-Russian propaganda on social media; faking pro-Russian foreign policy books by Western authors published in Russia; employing automated bots to generate complaints on anti-Russian or pro-Western Twitter users; and inventing news stories that are picked up by other states and agencies and run as factual reports.[44] Other operations range from "disinformation spread by social media trolls and bots, to fake-news sites backed by spurious polls, to forged documents, to online harassment campaigns of investigative journalists and public figures that stand opposed to Russia."[45]

In 2016 Russia interfered in the democratic process of the U.S. presidential election. The U.S. Senate's Select Committee on Intelligence conducted an in-depth review of the *Intelligence Community Assessment* produced by the Central Intelligence Agency, National Security Agency, and Federal Bureau of Investigation in January 2017 on Russian interference in the 2016 U.S. presidential election. Its findings show that Russia utilized "cyber-espionage and cyber-driven covert influence operations, conducted as part of a broader 'active measures' campaign that included overt messaging through Russian-controlled propaganda platforms."[46] This campaign was an extensive Russian information operation to sow discord among the American population and interfere in the democratic process of the presidential election. This campaign aimed to interfere in the elections primarily to undermine the trust of the American people in the security and validity of the democratic process, a primary outcome Russia saw as favorable to its long-term interests.

More recently, Russia has utilized its cyber capabilities for economic sabotage. In 2017, the Russian government used a virus known as NotPetya to disable Maersk, the world's largest container-shipping company. This company is a key node in global shipping as it traffics 80 percent of the world's trade.[47] The virus was subsequently used to disable several other international companies key to the global economy, including "an international snack company Mondelez, the U.S. pharmaceutical firm Merck and French, and a construction giant Saint-Gobain."[48] The effects of the virus caused chaos and widespread financial loss totaling approximately $10 billion.[49]

While the preceding examples are not a comprehensive account of every gray zone tactic Russia has used, the synopsis provides an impression of the breadth and complexity of the gray zone strategy that the United States must consider when attempting to deter actions at the sub-conventional level.

Stability–Instability Relationship

Deterring Russian gray zone aggression is not a simple matter. The United States and Russia sustain a multi-layered deterrence relationship anchored by the ever-present prospect of strategic nuclear exchanges. The complexity of escalation and deterrence dynamics is clearly evoked by the stability–instability paradox, which depicts how a stable strategic relationship can have perverse effects on deterrence prospects at lower levels of conflict, including gray zone conflict. Early in the Cold War, B. H. Liddell Hart estimated, "To the extent that the H-bomb reduces the likelihood of full-scale war, it increases the possibility of limited war pursued by widespread local aggression."[50] Glenn Snyder succinctly defined the stability–instability paradox: "The greater the stability of the 'strategic' balance of terror, the lower the stability of the overall balance at lower levels of violence."[51]

The logic of this effect is straightforward. Nuclear weapons and the prospect of mutually assured destruction stabilize the strategic deterrence relationship of states at the nuclear level. But this stability unleashes states to compete at the conventional level because strategic stability undermines the credibility of threatening to escalate to strategic weapons in response to conventional attacks. When an adversary is considering its decision calculus, nuclear weapons factor into a "whole war" or "total cost-gain" expectation.[52] An adversary would not want to take action at the conventional level that could reasonably be expected to escalate the conflict and cause devastating costs at the strategic nuclear level. Thus, nuclear weapons may moderate the types or intensity of action between states at the conventional level in some circumstances. But, conversely, if an adversary reasonably expects that an action at the conventional level would not escalate the conflict—precisely because of that devastating cost at the strategic nuclear level and the perceived durability of mutual massive destruction—then strategic nuclear stability has little conventional deterrence benefit. In fact, nuclear stability might incite certain forms of conventional aggression serving brinksmanship strategies. That is the stability–instability paradox: nuclear weapons always factor in via a "whole war" perspective, but how they factor in may be perverse.

Russia and the United States today maintain a relatively stable relationship at both the nuclear and conventional levels, but the sources of stability differ. While U.S.-Russian nuclear stability is based on parity, conventional stability in this relationship is more complex. Beyond the decisive initial period of war, or beyond Russia's near abroad, experts recognize that Russia is outmatched by the United States and NATO. The United States spends nearly 10 times more than Russia on national defense, holds a broad and sweeping technological advantage, and has a "vastly superior" ability to project military, economic, and political power across the globe.[53]

Because the United States and NATO maintain conventional superiority in most contexts, Russia has increasingly brandished nuclear escalation threats to keep that conventional advantage checked, eroding the "firewall" between these two levels. More importantly, and ironically, Russia's strategy of avoiding any actions that might trigger conventional conflict aims to bolster a parallel firewall between conventional warfare and gray zone conflict. NATO, up to now, has effectively obliged this Russian strategy by not even brandishing threats of conventional escalation in response to Russian gray zone aggression, let alone undertaking conventional responses. As much as Russia seeks to avoid escalation to conventional warfare it could not win, it is also learning how adverse NATO is to threaten such escalation. These respective Russian and NATO postures establish conventional stability but at the cost of fueling instability at the gray zone level, reflecting a form of the stability–instability paradox familiar in nuclear strategies.

This U.S.-Russian stability at the nuclear and conventional levels, situated in today's global security environment, has transposed the original nuclear/conventional stability–instability paradox to the conventional/gray-zone levels. This condition has liberated Russia's use of gray zone tactics despite its position of relative conventional weakness. As Alina Polyakova explains,

> Putin is no fool—he understands the limits of Russian capacities and ability to project power. Russia is no match to the

> United States economically, militarily, or in terms of its appeal to others. This is why the Kremlin has launched a strategy of political warfare against the West in the form of disinformation campaigns, support for far-right political parties in Europe, cyberattacks, money laundering, and other tools of influence that allow Moscow to undermine its perceived adversaries at very little cost. After all, it's cheaper to open an internet troll farm than to build tanks and invest in sustainable economic growth.[54]

Russia's wholesale commitment to a strategic approach relying on gray zone action reflects its expectation that both the constraints and opportunities of these conditions will endure. General Valery Gerasimov, chief of the general staff of the armed forces of Russia, envisions the future operational environment as follows:

> Less large-scale warfare; increased use of networked command-and-control systems, robotics, and high-precision weaponry; greater importance placed on interagency cooperation; more operations in urban terrain; a melding of offense and defense; and a general decrease in the differences between military activities at the strategic, operational, and tactical levels.[55]

Thus, the U.S.-Russian relationship today is embedded in a complex and intertwined security and political environment in which prospects of nuclear and conventional conflict complicate the application of deterrence postures to Russia's gray zone activities. While many familiar military deterrence routes are cut off, the expansive nature of gray zone engagement also opens possible avenues for novel deterrence strategies.

The Way Forward

The relationship between the United States and Russia is tenuous to say the least. The U.S. diplomatic climate recognizes Russia as an aggressive, toxic adversary, which leaves very few occasions to realize any opportunities for cooperation on mutually shared interests. Meanwhile, Russia maintains its historical expansionist tendencies not only territorially but also in terms of political influence, and President Putin continues to rely on fueling the belief that the West represents an existential threat to the Russian state in order to gain the domestic support he needs to stay in power.[56]

Nadia Schadlow wrote, "By failing to understand that the space between war and peace is not an empty one—but a landscape churning with political, economic, and security competitions that require constant attention—American foreign policy risks being reduced to a reactive and tactical emphasis on the military instrument by default."[57] Russia has shown determination in weakening the cohesion of the NATO alliance, diminishing U.S. involvement, gaining leverage in Europe, and achieving its strategic goals through the use of the gray zone. Russia's deep commitment to its strategic objectives, coupled with its regional balance-of-power advantage and lack of communication and trust with the West, makes it difficult for the United States to deter actions in the gray zone where aggression is difficult to attribute and actions are short of war. Difficult, but not impossible.

Developing a successful deterrent strategy requires engaging in the gray zone space and developing a posture of "cumulative deterrence" in which credibility can be sustained across multiple encounters even if deterrence fails in certain instances, in contrast with classic zero-tolerance nuclear deterrence.[58] It also relies on re-establishing diplomatic relations, consistent communication, and strategic touchpoints between the states. Currently, there are very few such opportunities, and the remaining consistent avenue of communication is between military leaders.[59]

Dr. Brad Roberts explains that the conflictual relationship between the United States and Russia does not have to be inevitable because "it is a matter of political calculus emanating from a particular person at a particular time."[60] This suggests that in order to restore diplomatic cooperation with Russia, President Putin must be persuaded that it is in his best interest to do so. Anthony Cordesman comments that "the U.S. tends to deal with Russia in terms of the sticks and often does not have a well-defined set of carrots."[61] Cordesman goes on to explain that a necessary addition to the sticks is "offering a well-defined alternative in terms of cooperation where the U.S. and Russia both benefit."[62] Operating a deterrent strategy solely on punishment is ineffective because, although it is imperative to signal to Russia that there are penalties for misbehavior, the United States must also signal assurance for compliance. This is a central but often overlooked principle of deterrence.[63] With established communication, diplomacy can facilitate that acceptable alternative and thereby bolster deterrence. More aspirationally, it can also build formal and informal agreements that bound conflict, decrease the risk of escalation, and provide insight toward understanding Russia's true intent.

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Review of the U.S. Army's Historical Nuclear Reactor Program

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The United States Army may be getting back into the business of nuclear power reactors. The Department of Defense Strategic Capabilities Office (DOD SCO) recently solicited for designs to prototype an inherently safe mobile nuclear reactor that can provide one to five megawatts of electricity. In 2016, the Defense Science Board (DSB) Task Force on Energy Systems[1] recommended to the Secretary of Defense that the Army should be the Executive Agent for nuclear energy applications. The Army G4's 2018 study on mobile nuclear power plants concluded that nuclear reactors could provide a continuous high-density power source to meet future force demands and the Army should support the DOD SCO prototyping effort and develop the requirement.[2] Many of the same factors drove the Army to pursue a nuclear reactor program in the 1950s, including a need to power remote stations in the event the Cold War became hot. Today our concerns are preparing for multi-domain operations with peer competitors where logistics will be contested.[3] The only nucler reactor that the Army currently manages is the fast burst reactor at White Sands Missile Range. Many young Army officers were born after the last historical Army power reactor shut down and are unaware of the program. This article will outline the Army's previous experience in managing nuclear power reactors.

The Army's nuclear power (electricity-generating) program operated from 1957 to 1976, spanning five U.S. presidents: Eisenhower, Kennedy, Johnson, Nixon, and Ford (see the timeline in Figure 1). Before the program, the first nuclear detonation occurred in 1945 with the first Soviet detonation in 1949. The Korean War was fought from 1950 to 1953. During this time the Army Nuclear Power Program, established in 1954, went online in 1957. That same year, the first commercial nuclear power plant, the Shippingport Atomic Power Station, went online. The last Army power reactor, the MH-1A Sturgis, was shut down in 1975 prior to the Three Mile Island accident in 1979.

The Army owned or helped design eight nuclear power reactors (see map in Figure 2). The naming convention of each reactor followed a two letter, number, and (optional) letter combination.[4] The first letter indicates the mobility of the reactor (S-stationary, P-portable, and M-mobile) where

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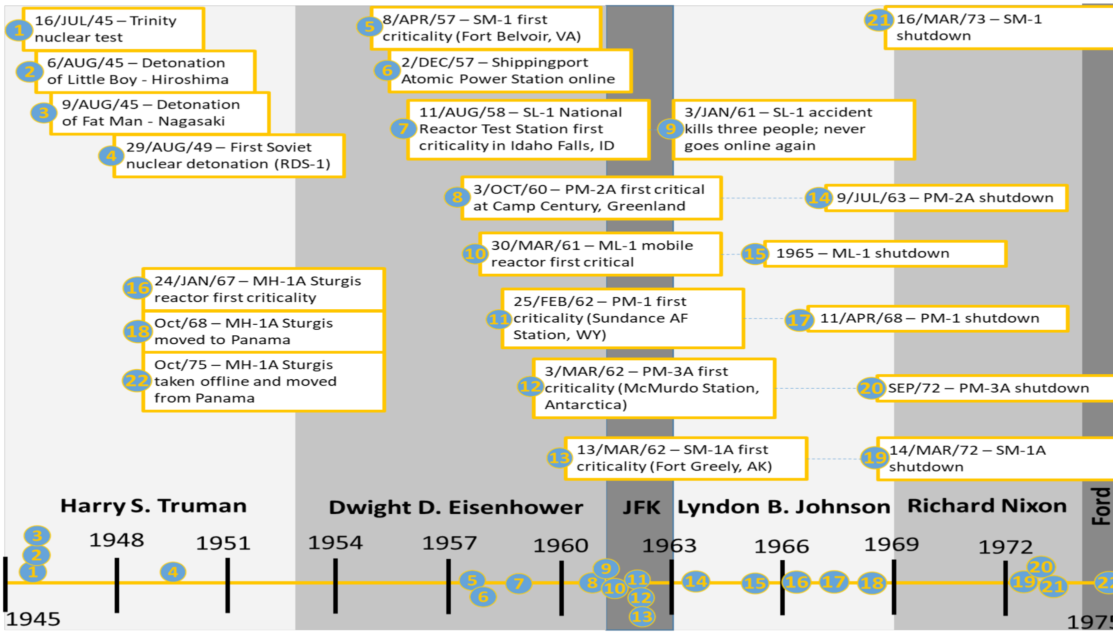

Figure 1: Timeline of the US Army nuclear reactor program. (Author produced graphic.)

"portable" means the reactor can be disassembled and assembled in another location, though not quickly moved, and "mobile" means the reactor is on a mobile platform, more rapidly placed. The second letter indicates the power (L-low, M-medium, and H-for high power). The third character is a number that indicates the order in which the models were initiated. If the number is followed by a letter, it indicates additional field plants of the same type in the order they were initiated. The first Army reactor to generate electricity was the SM-1 at Fort Belvoir, Virginia.

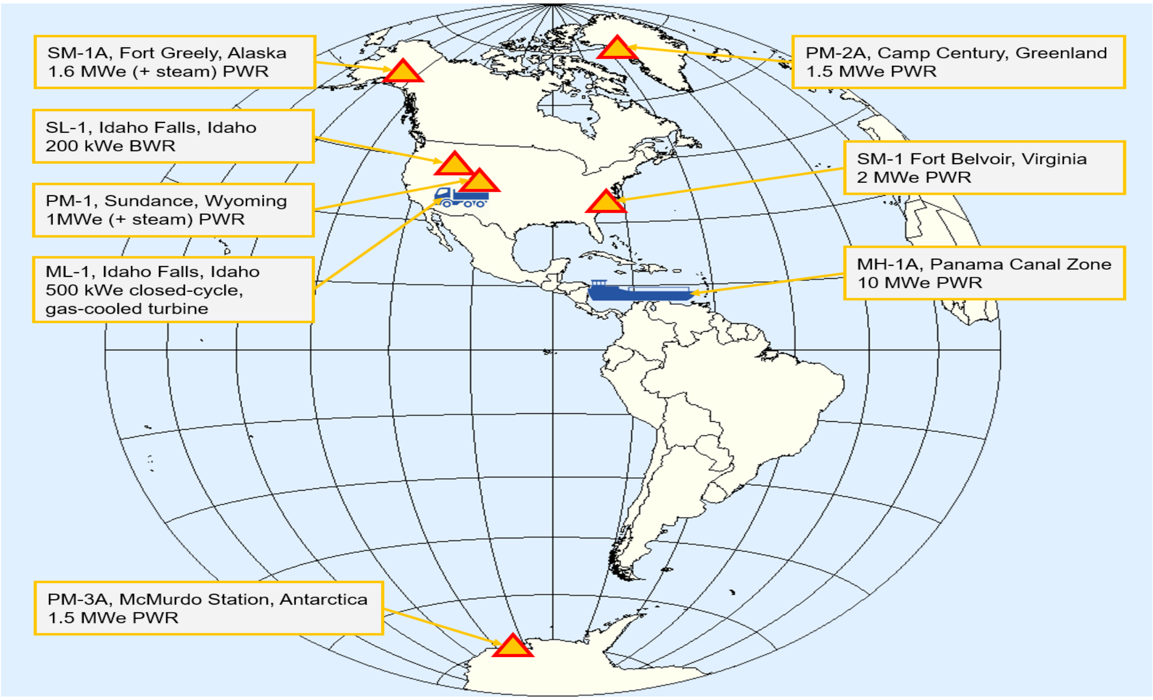

Figure 2: Map of U.S. Army nuclear reactor locations. (Author produced graphic.)[5]

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

The SM-1 was originally known as the APPR-1 (Army Package Power Reactor) but adopted the new nomenclature in 1958 for stationary, medium-power. American Locomotive from Schenectady, New York won the contract to build a prototype reactor in 1954 then renamed themselves ALCO in 1955. The SM-1 was built just 18 miles from the White House at Fort Belvoir, Virginia. It was a pressurized-water reactor (PWR) that produced 2 megawatts electrical (MWe) and achieved criticality for the first time on 8 April 1957. It generated electricity for the first time on 15 April and was the first nuclear plant to supply energy to a power grid.[6] The core consisted of highly enriched uranium clad in stainless steel. The SM-1 operated for 16 years and was used primarily as a training facility for the Army, Navy, and Air Force before it was shut down for the last time on 16 March 1973. The decommissioning and dismantlement of the site is scheduled from 2020-2025.[7]

SL-1, Idaho Falls, Idaho: 1958 - 1960

Argonne National Laboratories in Illinois designed the Stationary Low Power Reactor Number One (SL-1). Unlike the SM-1, this boiling water reactor (BWR) design was much smaller and less expensive since it did not require a large heat exchanger. The boiling water was its own steam generator, providing steam directly to the turbine. The SL-1 had the first aluminum alloy-clad fuel elements. The Fegles Construction Company constructed the reactor near Idaho Falls, Idaho. Though it was under the control of the Atomic Energy Commission (AEC), Army, Navy, and Air Force crews operated it. The SL-1 reactor first achieved criticality on 11 August 1958 and produced electricity for the first time on 24 October. It provided only 200 kilowatts electrical (kWe). The plant facility expanded to include training spaces and was used to develop U.S. expertise on the operation of BWR reactors. It operated safely for two years before catastrophe.

Figure 3: Aerial view of the SM-1 in the 1960's.[8]

The SL-1 shut down for routine maintenance on 23 December 1960. Then, at 9:01 pm, on 3 January 1961, while preparing to resume operations, an explosion occurred in the core. After several investigations it was determined that the SL-1 suffered from a safety design flaw. Specifically this flaw precluded full control of criticality within the core if only one of its five control rods were out of alignment. Based on this design, if the crew raised only the central control rod, the core could go critical. During previous operations, the aluminum cladding on the control rods had warped, occasionally causing the control rods to stick. Despite this the crews continued to train and learn on the SL-1 without incident and were not concerned with the slight warping. During the restart of the SL-1, one of the final steps to resume operations was to raise the central control rod only 1.5 inches to reconnect the drive mechanism. When attempting to do so, the control rod got stuck. The operator leaned over to manually lift the control rod. By doing so, the rod sprung loose. It rose high enough to cause a criticality event, superheating the reactor coolant, causing a steam explosion. This explosion raised the reactor nine feet off the ground, shearing all piping connections, destroying the core itself, and resulting in three fatalities. Two operators were found on the floor near the reactor, one still alive. He was exposed to an area receiving 1000 roentgen per hour and died on the way to the hospital. They later found the body of the third operator impaled to the ceiling by the central control rod.

The SL-1 was located in a sparsely populated area and no significant radiation escaped the immediate vicinity of the reactor building. The reactor was found in a non-critical state and completely dry. As long as no water was in the reactor vessel, there was no chance of another nuclear excursion. General Electric was awarded the contract to evaluate the site and completely clear the area. By 27 July 1962 there was no sign of a previously existing nuclear reactor or radioactive incident on the site. The SL-1 event remains the only American nuclear reactor accident to result in fatalities.[9]

PM-2A, Camp Century, Greenland: 1960 – 1963

ALCO designed the PM-2A as a portable medium-power PWR reactor to be placed at a remote outpost in Greenland. 400 tons of equipment was designed and built to be moved by plane and bobsled to Camp Century, Greenland and then constructed on an ice sheet. Camp Century was built inside deep trenches covered by a roof of steel arches. Due to harsh conditions, the well-trained team of Soldiers and contractors at Camp Century worked hand-in-hand to construct and test components simultaneously. On 3 October 1960 PM-2A reached first criticality, but was intentionally scrammed for further construction work. On 12 November 1960, the PM-2A was finally brought to full power, providing electricity to Camp Century, becoming the first Army field reactor to come online. Soon after coming online, the crew detected high radiation levels outside the reactor vessel. The reactor was shut down until two-inch-thick lead plates could be emplaced around the vessel. On 7 February 1961 the reactor was brought to criticality and two days later was supplying power once again. The PWR could provide 1.5 MWe plus heat to melt snow which provided water for the reactor and the base.[10]

The PM-2A demonstrated that nuclear power could provide energy to remote locations. However, U.S. military activity at Camp Century eventually declined. Costs continued to rise as buildings required constant repairs and snow arches had to be adjusted. Buildings and tunnels were at risk of being crushed under the snow arches. On 9 July 1963, the PM-2A was shut down for maintenance and the Army decided not to resume operations. Operators quickly winterized the reactor and demonstrated that the portable reactor could be disassembled in a remote location and moved.[11]

ML-1, Nuclear Reactor Testing Station, Idaho: 1961 – 1965

The mobile, low-power reactor, ML-1, became the first truck-mounted nuclear reactor. The reactor had a closed-cycle, nitrogen-cooled system and used water as a neutron moderator. The nitrogen gas heated in the core drove the turbine and then returned to the core. Aerojet-General built the ML-1 in Downey, California and transported it on a low-bed trailer to the National Reactor Testing Station in Idaho. The ML-1 achieved first criticality on 30 March 1961. 18 months later, the ML-1 operated as a power plant providing a few kilowatts of electricity in a test on 21 September 1962.[12] The mobile reactor had three packages: a 15-ton reactor, a 3-ton transistor control cab, and another 15-ton electric converter. An additional four auxiliary packages brought the total weight of the ML-1 to 40 tons enabling it to provide 300 to 500 kWe.[13]

The ML-1 continued a series of tests, reaching full power in February 1963. Over its lifetime it suffered several deficiencies, including coolant gas leaking into the moderator water. The system was repaired and regained full power in the Spring of 1964. With budget cuts and indications of emitting radiation, the ML-1 was shut down in the summer of 1965 and never tested again. This ended the Army's efforts to develop land-based mobile reactors. From the SL-1, the ML-1, and support to the National Aeronautics and Space Administration's Lunar Landing Program, Army Engineers learned that compact nuclear power plants are expensive, time-consuming, and only justified if a reactor fills a unique capability with clearly defined objectives.[14]

PM-1, Sundance Air Force Base, Wyoming: 1962 – 1968

The effort to produce the PM-1 started before the PM-2A in Greenland but was completed later. The Army supported the design of the PM-1 to operate in a remote location but later transferred it to the Air Force at the Sundance Air Force Radar Station in Wyoming. Sundance AF Station was home to the 731st Radar Squadron of the North American Air Defense Command. The AEC and Air Force awarded Martin Company the contract to design and construct the PM-1 to provide 1 MWe plus steam to provide heat to the base. The PM-1 was a PWR with no containment vessel. The core was about the size of a 55-gallon drum and the primary system was placed underground in three storage tanks. The initial crew consisted of personnel from the Air Force, Army, and Navy. The PM-1 attained first criticality on 25 February 1962 and provided power to Sundance for the first time in April 1962.[15] The Air Force assumed control from the Army Corps of Engineers on 31 October 1962, with the Engineers continuing to provide technical support for the reactor. Its final shutdown was on 11 April 1968, when the Air Force closed the Sundance Radar facility. This marked a major decline in the Army nuclear reactor program.

PM-3A, McMurdo Station, Antarctica: 1962 – 1972

The PM-3A was yet a third portable, medium-powered model, required by the U.S. Navy to power facilities in Antarctica. Again, the Army Corps of Engineers was involved in supervising the reactor's development. The Martin Company won the contract to design and fabricate a reactor similar to the PM-1. The reactor was built at McMurdo Sound, on Ross Island, Antarctica. The PM-3A reached first criticality on 3 March 1962 and supplied power to McMurdo Station on 10 July 1962. It was a 1.5 MWe PWR with the primary system placed underground, like the PM-1. The crew consisted of Navy, Air Force, and Army personnel, all trained at Fort Belvoir and certified on other reactors before conducting a tour at McMurdo Sound.

The PM-3A was shut down in September 1972 to inspect possible water leaking from the shield surrounding the containment vessel.[16] After 11 years of service, analysis suggested a modern turbine and oil-based power plant was more cost-effective; the PM-3A never came back online. In March 1973 plans for decommissioning the reactor began. By Antarctica's 1975-76 shipping season, all reactor structures and supporting facilities had been removed.

SM-1A, Fort Greely, Alaska: 1962 – 1972

The SM-1A was one of the first reactors the Army considered. Peter Kiewit Son's Construction Company of Seattle won the contract on 26 April 1958. Kiewit then subcontracted the nuclear components of the reactor to ALCO for production. The SM-1A was a PWR designed for 1,640 kWe and steam for heat to support Fort Greely, Alaska. The reactor would operate near military personnel; therefore, it required a reliable vapor containment system. SM-1A also had to use well water that needed a water-softening process to support the reactor. Construction had to take place from May to September with little work taking place the first year. During the 1959 work season, there was an Alaska-wide strike that further delayed construction. Components of the core were constructed in New York by ALCO and shipped via rail to Seattle, then by ship to Valdez, and finally by truck to Fort Greely. If damage occurred during shipment, components had to be returned to New York for repair. The SM-1A finally went critical on 13 March 1962. On 23 April 1962 the reactor provided Fort Greely with electricity and steam for the first time.

Ten years later, on 14 March 1972 the SM-1A was shut down for the last time. The Army Corps of Engineers decided that the SM-1A had completed its mission of demonstrating the feasibility of nuclear reactors in remote arctic conditions and would turn over power requirements to a diesel power plant. Instead of removing the entire facility, the reactor vessel was entombed in concrete. New decommissioning planning is anticipated to be complete by 2021 with work planned to start in 2022 or 2023.[17]

MH-1A, Panama Canal Zone: 1967 – 1976

The last Army nuclear power reactor to start and stop was the MH-1A, mobile, high-power reactor. The Martin Company won the contract to construct a nuclear power barge. The World War II Liberty ship, *SS Charles H. Cugle*, was stripped, had its propulsion system removed, and reconfigured into the *USS Sturgis*. With its new PWR reactor capable of providing 10 MWe, the MH-1A reached first criticality on 24 January 1967 at Fort Belvoir, Virginia. This was the only reactor in the Army program to use low enriched uranium. The *USS Sturgis* provided power to Fort Belvoir during testing and after final approval in July 1967. In 1968 the *USS Sturgis* was towed to Panama and on 5 October began providing power to the Panama Canal Company power grid. Power provided by the MH-1A enabled the hydroelectric

Figure 4. The *USS Sturgis* providing power to the Panama Canal.[19]

dam to release more water into the Canal during dry seasons, allowing many more boats to traverse the Canal. For about eight years the *USS Sturgis* provided nuclear power to the Panama Canal as Army personnel rotated to operate and maintain the ship.[18]

By late 1976, the Panama Canal Company developed other power options. With the decision to turn the Canal over to Panama, the U.S. decided to return the *USS Sturgis* to Fort Belvoir. In December 1976 the barge left Panama and arrived at Fort Belvoir in January 1977. With no suitable location for continued use, the Army planned the *USS Sturgis* to be decommissioned and moved to the James River Reserve Fleet in early 1978. In 2015 the *USS Sturgis* was towed to Galveston, Texas for final decommissioning and dismantling. After removing all radioactive material and recycling the lead, the barge was moved to Brownsville, Texas in 2018 for traditional shipbreaking, which finished in March 2019.

Then and Now

With the last of the Army nuclear power reactors shut down over 43 years ago in 1976, two major similarities exist in the former program and new efforts: the need to stimulate the nuclear industry and the need to reduce logistics trails to remote locations. In the 1950s, the U.S. nuclear industry needed government support to fuel the commercial industry. Currently the U.S. nuclear industry has few new reactor licenses and U.S. enriched uranium production is at an all-time low.[20] Many in the nuclear industry see advanced designs of smaller reactors as commercially viable.[21, 22, 23, 24, 25] By funding a small modular reactor prototype, the DOD will stimulate the small reactor industry which might lead to commercial growth.

The Army program of the 1950s was tied to supplying energy to remote bases, reducing requirements to secure transport fossil fuels to those locations. The same concerns over the tether of fossil fuel logistics drive the new effort. The DSB Task Force on Energy Systems report focused on small nuclear reactors as the solution to the sustainment challenges of delivering energy to the tip of the spear.[26]

However, a lot has changed since the beginning of the Army reactor program. Scientists and engineers learned quite a bit since the first reactors were designed. The safety culture around nuclear reactors has also evolved. In the beginning, computational fluid dynamics calculations, fault tree analysis, or total system assessments did not exist. Today, the advanced nuclear reactors considered by the DSB are quite different than older versions. Similar to the MH-1A, new designs do not use highly enriched uranium and therefore do not pose a proliferation risk. The fuel itself is much safer. Some current proposals use tri-structural isotropic particles for fuel. These are poppy seed-sized particles composed of high assay – low enriched uranium coated in carbon and silicon-carbide that contain fission products within the particle and can withstand the extremely high temperatures of the new advanced reactor designs.[27, 28] Using such fuel is safer and less prone to nuclear proliferation.

DOD SCO posted a request for solutions on FedBizOpps in April 2019 for small nuclear reactor designs. After down-select, the next phase will fund an operational prototype by 2023. Lessons learned from current efforts will be just as insightful as lessons learned from our past. The original reactor program proved that nuclear power could be used in forward support areas. Although we face the same problems as the old program, we now know that initial design costs and lifecycle costs of unique reactors are burdensome. We must minimize those costs through a careful selection process. The Army must have clearly defined objectives, with unique capability requirements that only small mobile nuclear reactors can solve before getting back into the business of nuclear reactors.

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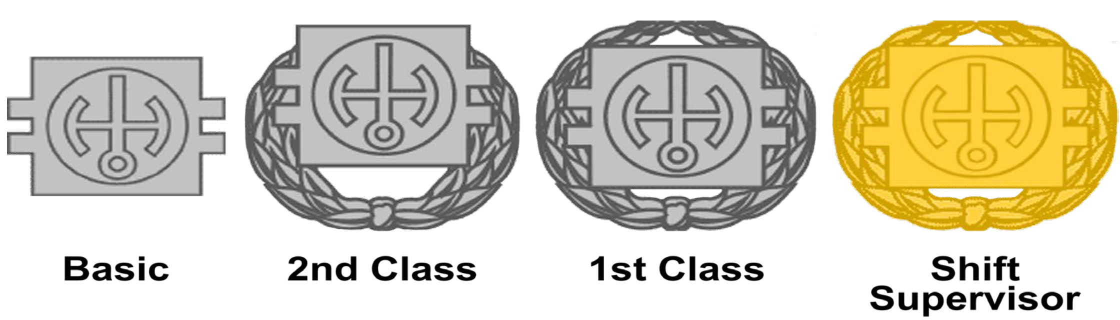

Insert: U.S. Army Qualification Badges for Nuclear Reactor Operators

An Overview of the Plutonium Management and Disposition Agreement

MAJ Luke A. Tyree
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The United States ushered in an age of strategic nuclear deterrence with the detonation of two nuclear bombs on Japan in 1945. With the existence of nuclear weapons came two opposing efforts among states on the world stage: the effort to build nuclear weapon stockpiles competing with bilateral and multilateral efforts to limit and reduce existing stockpiles. One arms control measure between the United States and Russia is the Plutonium Management and Disposition Agreement (PMDA) which commits both countries to dispose of excess weapons grade plutonium in their stockpiles. Russia and the United States have settled on two divergent plutonium disposition pathways that are perhaps partially reflective of how the two countries view the nature of plutonium: Russia views plutonium as a valuable energy resource while the United States views plutonium as something dangerous that needs to be eliminated.

During the nuclear arms race of the Cold War, the United States and Russia accumulated a very large amount of plutonium and highly enriched uranium (HEU) in their nuclear weapon stockpiles – significantly more special nuclear material than any other nuclear weapon state. Weapons grade plutonium is defined as plutonium with less than 7% of Pu240 and HEU is uranium enriched to 20% U235. The United States and Russia would ultimately designate tens of tons of weapons grade plutonium and hundreds of tons of HEU to exceed their defense requirements. On the other hand, other nuclear weapon states such as France and the UK had less than ten tons of plutonium and between 20 to 30 tons of HEU total in their nuclear weapon stockpiles. Following the conclusion of the Cold War, the United States and Russia began serious deliberation on how to reduce the number of nuclear warheads and the amount of fissile material (plutonium and HEU) in their respective military stockpiles.[1]

Once the United States and Russia recognized the issue of excess plutonium and HEU, the two countries identified the need to successfully dispose of these materials. HEU must be converted to low enriched uranium by downblending the material. While the downblending process for HEU does rely on some technically sophisticated processes, it is comparatively straightforward when compared to the disposition of excess weapons grade plutonium. Downblending reduces the concentration of U235 by mixing with U238 as either a liquid or gas. This method is practical for

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HEU because uranium's natural enrichment is 99.3% U238. Plutonium on the other hand is a synthetic element produced in nuclear reactors. Other isotopes of plutonium do not exist in sufficient quantities to make downblending Pu239 with Pu240 or other plutonium isotopes a practical option.[1]

Due to the complicated nature of plutonium disposition, General Brent Scowcroft, President George H.W. Bush's National Security Advisor, asked the National Academy of Sciences' (NAS) Committee on International Security and Arms Control (CISAC) to conduct a "full-scale study of the management and disposition options for plutonium."[2] The Clinton administration subsequently confirmed CISAC's mandate to conduct this study in January 1993 and NAS published the "Management and Disposition of Excess Weapons Plutonium" in 1994.[2]

The NAS study considered multiple disposition methods for the excess plutonium including: "sub-seabed disposal, launching the material into the sun or out of the solar system, and even considered a Russian proposal to explode a nuclear device surrounded by plutonium pits underground."[1] Regardless of the method proposed, the NAS study had to ensure it met the spent fuel standard (SFS). The SFS stipulated that plutonium disposition processes should make the plutonium "as inaccessible for weapons use as the much larger and growing quantity of plutonium that exists in spent fuel from commercial reactors."[2] The two options that were ultimately recommended were:

1) Burn the excess plutonium in existing commercial reactors as plutonium-uranium mixed oxide (MOX) fuel.
2) Immobilize the plutonium with high level radioactive wastes.

The immobilization of the plutonium and high level wastes would be accomplished either through sealing it in glass material, called vitrification, or in a ceramic material, called ceramification.[1] Both options, MOX and immobilization, met the SFS requirements and thus were viable options for disposing of the excess plutonium as identified for the PMDA.

The United States and Russia signed the PMDA in 2000. The PMDA commits each side to verifiably dispose of 34 tons of weapons-grade plutonium removed from each country's nuclear weapons program and confirmed through verification methods. In 2006 and 2010, the United States and Russia signed protocols adjusting the original agreement.[3] One of the main provisions that were modified allowed Russia to burn its MOX fuel in fast reactors rather than light water reactors. Russia's justification was that this disposition strategy would be more congruent with its long term energy strategy.[5] Currently, neither side has met the non-binding commitment to begin plutonium disposition by 2018.[3]

The United States pursued the disposition strategy of burning the plutonium in the form of MOX fuel in commercial light water reactors. To make the MOX fuel, the United States needed to construct a facility that could make the MOX fuel assemblies. The plan was to build the MOX Fuel Fabrication Facility (MFFF) at the Savannah River Site. Faced with the project being over budget and overschedule the Obama administration proposed canceling the facility and pursuing a "dilute and dispose" option for plutonium disposition. The diluted plutonium would be disposed of at the Waste Isolation Pilot Plant (WIPP) in New Mexico. This action prompted Vladimir Putin to argue that the United States was not living up to its obligations under the PMDA and consequently withdrew from the PMDA in 2016.

The United States continues to maintain the position that the PMDA is still in effect and is maintaining its obligations. The 2018 disposition initiation date is non-binding, and the United States is within the terms of the agreement in choosing to pursue a "dilute and dispose" plutonium disposition pathway. In 2019 the United States stated in its "Adherence to and Compliance with Arms Control, Nonproliferation, and Disarmament Agreements and Commitments" report that it will reengage Russia on its role in the PMDA once the United States is prepared to begin plutonium disposition.[3] According to a National Academies of Science report published in 2018, it will take 31 years for the United States to complete the "dilute and dispose" process of the 34 tons of excess plutonium, starting from the initial design process in 2018 through the ultimate placement of the diluted plutonium at WIPP in 2049.[4]

In conclusion, the United States has publicly declared that it will pursue a "dilute and dispose" plutonium disposition pathway – abandoning its plan to construct the MFFF and transmute the plutonium as MOX in commercial light water reactors. The United States maintains that this decision is within the terms of the PMDA.[3] The two methods chosen by the United States and Russia reflect the two countries' divergent views on plutonium. The United States sees plutonium as something dangerous to be eliminated as a proliferation risk. Russia sees the plutonium as a valuable energy resource to be exploited. These two divergent views may partially explain why Russia has been able to achieve its disposition pathway while the United States is still working through a plutonium disposition strategy.

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CBRN Situational Awareness Tools for the Modern Age

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U.S. Armed Forces are re-posturing to address peer and near-peer conflict as a result of the 2018 National Security Strategy, National Defense Strategy, and Nuclear Posture Review documents. Our armed forces are preparing for the possibility of a return to a battlefield that presents hazards across the chemical, biological, radiological, and nuclear (CBRN) spectrum, most prominently including nuclear weapons use, in many ways picking up where the Cold War left off. The United States faces a more diverse and advanced nuclear threat from potential peer-adversaries' development and deployment programs for nuclear weapons and delivery systems.[1] Potential radiological and nuclear weapons use may not be limited to strategic engagements. Opposing conventional forces could deploy nuclear weapons or radiological devices to delay friendly forces or produce non-nuclear effects, such as severe electromagnetic interference.[2] The characteristics of conventional-nuclear integration (CNI) across the land, sea, and air domains share similarities with the consequence management mission of domestic CBRN responders. However, warfighters on a radiologically contaminated battlefield must be protected and make informed risk-based decisions from mixed hazards while continuing to prosecute an engagement, making for an altogether greater challenge.

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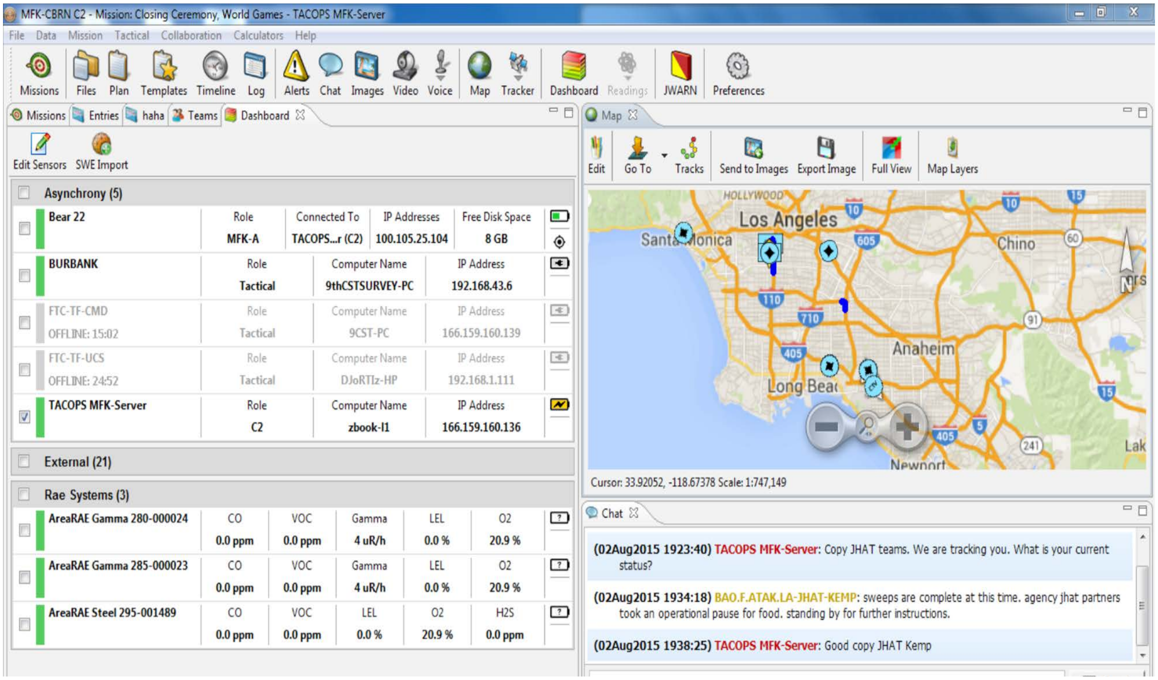

Figure 1. Example of the MFK user interface showing a table of sensors, including readings; a map with icons for sensors and personnel; and the chat window.

CBRN situational awareness should be a key operational requirement in the CNI area of discussion, for both the "boots-on-the-ground" warfighter and those operating at a strategic level. For example, maneuver plans need to be developed for contamination avoidance and battlefield survivability. Large instrumentation datasets dispersed across the battlefield can collect and process information into a holistic assessment of hazards. CBRN hazard maps can then be distributed at the tactical level—while continuing to effectively engage peer adversaries. This vision represents a network of sensors, software tools, data processing algorithms, communications suites, and common operational picture platforms working in concert to inform warfighters and command echelons of evolving nuclear and radiological hazards. This complex system-of-systems enabling a goal of effective engagement in a nuclear or radiological-hazard battlefield can be achieved through the pursuit of improvement in collaborative situational awareness tools.

Mobile Field Kit and Tactical Assault Kit

The Mobile Field Kit (MFK) is a Windows PC-based common operating picture primarily used to remotely transmit sensor readings.[3] MFK was first developed for the Navy Explosive Ordnance Disposal mission to enable technical reach back to incident commanders and subject matter experts by providing real-time sensor readings over a wireless network. Previously, the readings would be communicated by voice over radio frequencies. Although sensors are still the primary focus, the MFK tool includes support for mobile devices, user chat, maps and map editing, media sharing, and mission planning. MFK is based on a "hub-and-spoke" system architecture, where one software instance (the server) functions as the point of contact for all mission members (clients). MFK clients use a "store-and-forward" approach in the case of disconnection from the network server. Information is collected and stored on the local device until a connection is reestablished, at which point the client begins

Figure 2. Example of the RN plugin for ATAK, showing connection to a radiation sensor with gamma and neutron detection capability, count rates for each radiation type plus dose rate, and a map with heat indicators proportional to dose rate.

synchronizing with the network server. An MFK example is presented in Figure 1 showing the table of sensor connections, the map, and chat features.

The Tactical Assault Kit (TAK) also known as "Team Awareness Kit", is a situational awareness software ecosystem with versions developed for the Android Operating System (ATAK) and Windows PCs (WinTAK).[4] TAK is primarily geospatially driven, but also supports team collaboration capabilities including user chat, image sharing, map markup, document sharing, and video streaming. ATAK supports a plug-in architecture featuring radiation sensor support, laser detection and ranging (LIDAR) imaging, and a parachute jump calculator.[5] TAK also functions based on a "hub-and-spoke" model, with a Linux-based TAK server acting as a message router between devices. Multicast networks, typically employed with mesh networking and tactical radios, can be used instead of the land-based server. TAK is network agnostic and can be used with most existing networks including WiFi and cellular networking. An ATAK example is presented in Figure 2, depicting of the radiological and nuclear (RN) plugin, designed to connect to radiation sensors.

Case Study: Boston Marathon

An exemplary case study in expanding situational awareness capabilities through tool interoperability is found in the deployment of situational awareness tools and infrastructure at the Boston Marathon. Authorities deployed both the MFK and ATK situation awareness tools.

The 1st WMD Civil Support Team (CST) of Massachusetts employed MFK as part of their situational awareness communications architecture shown in Figure 3 during the 2014 Boston Marathon. MFK tactical (TAC) nodes were required for each CBRN sensor-set to feed data to the MFK command and control (C2) node via cellular connection and via Trellisware® (TW)

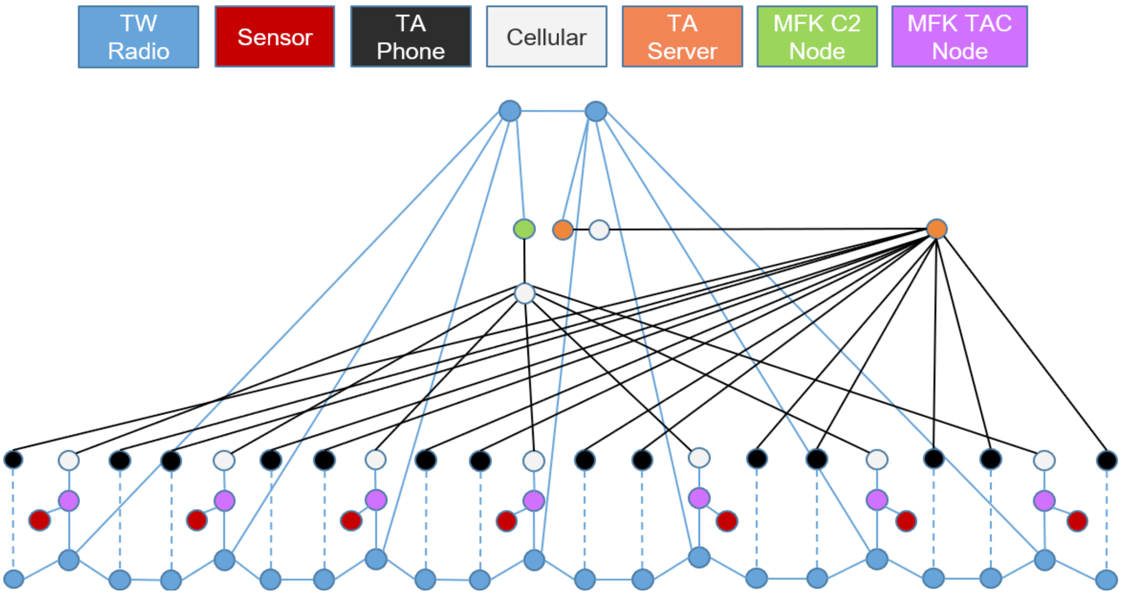

Figure 3. Situational awareness network architecture deployed to support the 2014 Boston Marathon. The dashed lines indicate the as-needed hardline backup connection between the Transformative Apps (TA) phones and the Trellisware (TW) tactical radios.[4]

tactical radio network.[6] Transformative Apps (TA) mobile nodes and servers were used for the event but were not fully integrated with the MFK network.[7] As a result two separate information networks were connected via hardline as a backup, and were used as needed.

In 2015, MFK achieved interoperability with the TAK ecosystem. Due to this new capability the situational awareness network architecture deployed by the 1st CST to the 2015 Boston Marathon, as shown in Figure 4, was substantially different from 2014. ATAK mobile devices and TAK servers replaced the Transformative Apps mobile devices and servers of 2014. During this mission, ATAK was able to transmit sensor, chat, and map data from MFK TAC nodes to MFK server instances running at both the Defense Threat Reduction Agency Headquarters (DTRA) and each end of the marathon route. Two benefits were realized: (1) the tactical radio mesh network from 2014 was not needed, freeing operators from maintaining it, and (2) CSTs and local authorities enjoyed better coordination. Local authorities had access to ATAK via their mobile devices and could merge their servers with the CSTs. Since that time, the combined operation of MFK and ATAK has provided a key operational capability for many National Guard CSTs.

CNI Battlefield Challenges

Maintaining CBRN situational awareness will be significantly more challenging in near-peer and peer-to-peer battlefield engagements compared to current civilian operations. Compared to domestic response missions, the CNI battlespace includes more individual users, more echelons of command, combined arms, wider areas of operation, a more varied and unpredictable environment, and longer duration. Scaled battlefield situational awareness support needs to include the following elements to achieve success:

- Bandwidth management to accommodate hundreds to thousands of users and devices across multiple echelons of command.

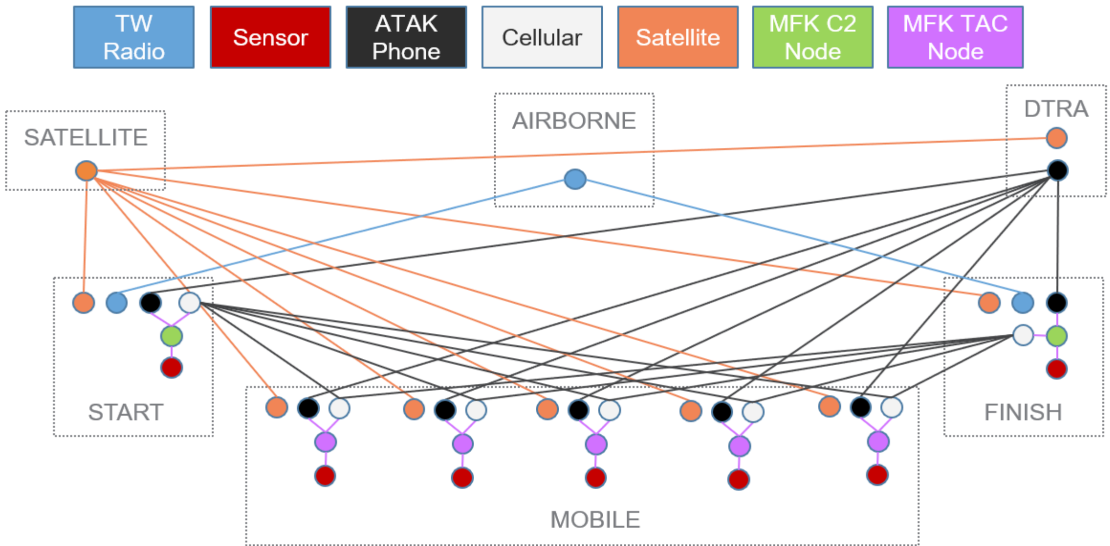

Figure 4. Situational Awareness network architecture deployed to support the 2015 Boston Marathon. Satellite connections, cellular auxiliary connections, tactical radio, and mobile phones were all used to provide an integrated network with multiple backups, including an airborne tactical radio node connecting the start and finish lines.[8]

- Differentiation and accommodation of different unit types to support combined arms operations.
- System abstractions and tool features for hundreds to thousands of users across a wide-ranging area of operation.
- Ruggedness and longevity to operate continuously for days.
- Meshing, ad-hoc, and self-repairing networks to maintain a mobile and resilient infrastructure.

CBRN situational awareness tools on the battlefield must be able to operate in a distributed, dynamic, real-time environment that demands intense computational processing and data telemetry and do so at large scale. Even though MFK was successful with CSTs in response missions, the software proved unsuited for standby mission tasks. The increased number of sensors and operators combined with the longer duration of standby missions paralyzed the CST communications network. The introduction of an ATAK-MFK interoperability paradigm cross-loaded network traffic to cellular communications, freeing up the CST network for other uses and only required local MFK use. While further improvements have been made to these tools since their adaptation to the domestic standby mission, their suitability to CNI operations will require a thorough and rigorous evaluation and development that includes reliability, security, scalability, and stress-testing at large-scale exercises and operational experiments.

The Age of Enlightenment

Technologies to overcome CBRN situational awareness tool complications are emerging. Cloud-based enterprise application software and fifth-generation (5G) communications are two promising candidates that can help overcome the difficulties of scale for the CNI mission.

Already, a cloud-based version of MFK called MFK Enterprise (MFK-E) is under development at DTRA to answer the challenges of ease of collaboration and the ability to handle a much larger deployment scale.[9] MFK-E will allow direct server connections between MFK command and control servers without the need to integrate with TAK or directly connect the two servers, providing a more robust architecture with better data sharing. MFK-E can also be used for large-scale mission planning, incorporating the ability to import personnel, teams, equipment, and files from MFK C2 servers—effectively connecting multiple MFK enclaves to a single mission planning center. MFK-E enables more effective coordination and response across multiple National Guard CSTs. The cloud-based architecture also enables access for state, local, and interagency partners by providing a login portal for approved users. Information sharing settings in MFK-E will allow users to share different types and amounts of data with their interagency partners at any location, including on-scene liaison officers, emergency managers at local emergency operations centers, and technical reach back advisors at remote laboratories. For example, a CST might share technical data from its sensors with a coordinating CBRN Enhanced Response Force Package (CERFP), while the CERFP might share its triage, cost, and damage assessment values with local command and state authorities.

The large-scale user capability of MFK-E could be easily adapted to the CNI mission. For example, an infantry reconnaissance squad would share its position and sensor data with its battalion and brigade to warn of CBRN hazards or threats. A battalion commander would use this enterprise solution to coordinate operations while an entry team investigates a CBRN sensor anomaly. The enterprise nature of MFK-E is interoperable with other tools, such as Blue Force Tracker- and the Integrated Sensor Architecture-enabled platforms, where only a single interface between these tools and MFK-E would need to be established to distribute information to individual MFK field enclaves and individual users. Such interoperability would also enable information and data fusion techniques for improved situational awareness and decision support.

The success of MFK-ATAK interoperability stems from the ability of ATAK to use commercial cellular communications or high bandwidth Internet protocol-based mesh radio network instead of legacy radio equipment. This capability has enabled mission-critical information to be passed between mobile teams more quickly and efficiently. For response events where civilian cellular networks are overwhelmed, FirstNet offers a dedicated wireless spectrum range (Band 14, 700 MHz) accessible only to first responders, keeping critical communications available.[10] 5G cellular communications are projected to offer both of these capabilities through network slicing, with the added benefits of lower latency and higher maximum data throughput. Table 1 offers a comparison between 4G and 5G network capabilities. Of particular note is the ability for 5G networks to handle devices traveling at up to 500 km per hour, enabling device connectivity even for some aircraft, provided they are in the range of the network.

Low-latency high-performance computational resources will be enabled in part by embedding servers into the cellular network infrastructure thus enabling edge cloud computing.[10,11] When computation-intensive services require low-latency connectivity, such services can be deployed close to the user's point of attachment (e.g., a cell tower) and network traffic can be routed more efficiently. Amazon and Verizon are currently partnering to integrate Amazon Web Services (AWS) "WaveLength" into 5G infrastructure, which will place AWS

Parameter	4G LTE	5G
End-to-end Latency	50 ms	5 ms
Peak Data Rate	0.3 - 1 Gb/s	1 - 10 Gb/s
Maximum Device Velocity	10 km/h	500 km/h

Table 1. Comparison of 4G LTE and 5G cellular capabilities.[11, 12]

technologies closer to end-user devices.[13] This capability would enable data fusion at the network edge before transmitting fused information to higher echelons or technical reach back and would free up bandwidth for other data and communications in the CNI mission. In other scenarios, 5G will allow a mobile cell tower to be deployed with maneuver units to establish and maintain communications between distributed nodes, such as dismounted warfighters on a patrol or making entry into a target building with streaming CBRN sensor data, while also seamlessly providing compute capabilities similar to current cloud capabilities.

Edge computing with 5G capabilities will enable the deployment of technologies such as virtual-reality and mixed-reality and machine learning.[12, 14, 15] Virtual-reality and mixed reality (XR) devices such as the Microsoft HoloLens[16] and HTC Vive[17] require high-performance computing but also carry a competing requirement for small size and lightweight construction. 5G-based edge computing offers the necessary processing power while also providing low-latency connectivity to allow computing-intensive processes to be moved off the XR device. Edge computing makes XR devices a reality for the individual warfighter by keeping devices small and lightweight for dismounted operations. Edge computing capabilities distill, fuse, and correlate events with the proper sensor data allowing for better data streaming, for example from radiological or chemical sensors and any associated cameras or contextual sensor sources.

Integration of this technology is required to maximize future unmanned aerial and ground systems. Autonomous vehicles require similar computing-intensive processes to communicate with each other as well as traffic infrastructure to safely maneuver on roadways. While onboard sensors such as LIDAR provide situational awareness for immediate surroundings, the 5G "vehicle-to-everything" (V2X) ecosystem will allow low-latency, high-bandwidth communications with central traffic services that will, for example, coordinate on-ramp merging and alert the vehicle systems to beyond-line-of-sight obstructions or traffic jams. V2X services also act as a backup to onboard sensors in poor weather conditions or in the event of a sensor malfunction.[18, 19] This capability could aid unmanned aerial systems integration and reliability, allowing for better manual control and better coordination among multiple unmanned aerial systems platforms working together to accomplish a radiological mapping mission for contamination avoidance, for example.

Conclusion

The global geopolitical situation is changing and rising potential peer and near-peer adversaries may employ chemical, biological, radiological, and nuclear weapons in a strategic or regional conflict. The global situation drives the need for CNI and the corresponding need for strategic-level CBRN situational awareness tools. This must be accomplished through either further development of current tools or development of interoperability capability with current strategic situational awareness tools. In either case, current CBRN situational awareness tools such as MFK and TAK will face challenges of scale not yet encountered in their current domestic response application space. These challenges can be addressed through the development of cloud-based enterprise tools, such as MFK-E, which will aid information dissemination at the strategic level, and through greater connectivity enabled by technologies such as 5G communications. These developments will be critical for effective operations in a nuclear battlespace.

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Optimizing the Teaching of Technical Computing for CWMD at West Point

MAJ Andrew S. Wilhelm, MAJ Logan Phillips, and CPT(P) David Fobar
United States Military Academy

Within the nuclear enterprise, powerful computational tools are essential for a variety of applications such as weapons design, radiation detection, and power generation. Software programs such as Monte Carlo N-Particle (MCNP) enable engineers to simulate anything from nuclear reactor cores to neutron time-of-flight spectroscopy experiments. Other software applications used by nuclear engineers include the use of computer-aided design (CAD) software such as SolidWorks. However, many of these tools are non-intuitive and require users to possess a substantial amount of experience with scientific and technical computing. Despite the necessity of such skill, students of nuclear engineering often lack the time to complete a robust sequence of computer science. Thus, it falls to nuclear engineering programs to incorporate the skills of basic coding, modeling, and technical computing into their instruction.

Teaching technical computing across any discipline can become a frustrating endeavor for both faculty and students. Even the smallest of missteps in syntax or process can completely derail a student's ability to continue with lesson progression. As a result, instructors must constantly

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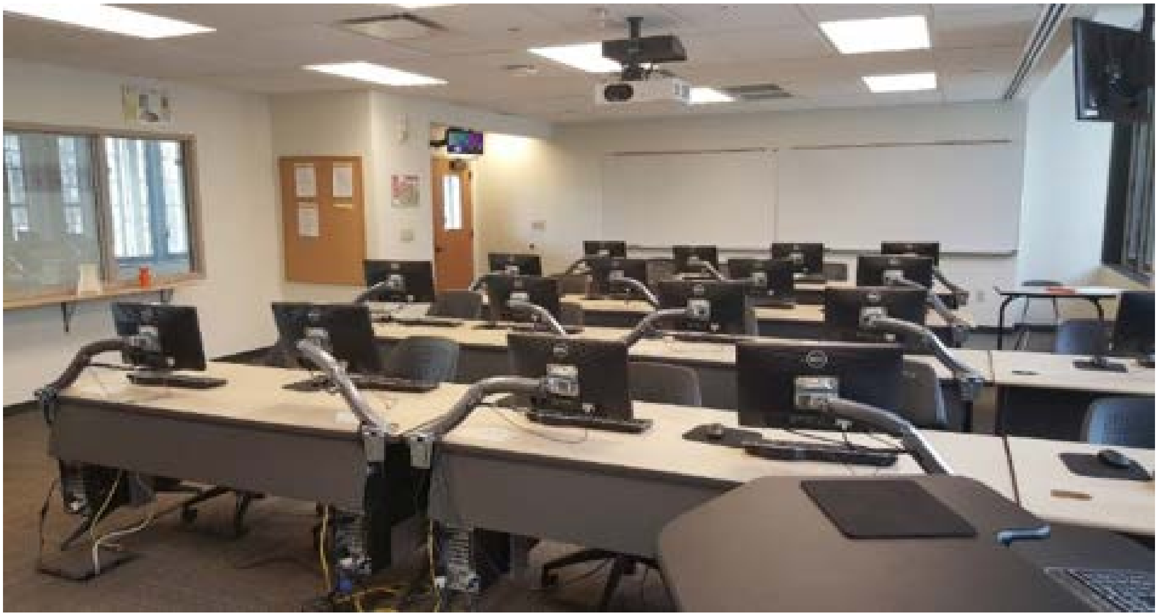

Figure 1. A typical computer laboratory. Students all face the front of the classroom, and the instructor cannot see any of their screens.

balance time between instruction, student assessment, and troubleshooting. Maneuvering the pedagogical and physical space of such a class can be challenging for any instructor. The result – struggling students and vexed instructors.

However, recent classroom advancements indicate there may be a better way to optimize student learning. The newly constructed West Point Department of Physics and Nuclear Engineering (D/PaNE) Computer Instructional Facility (CIF) was specifically designed and constructed with these challenges in mind. Initial assessments appear to show dramatic improvement in both the student and faculty experience of a technical computing learning environment.

Pitfalls of the 'Standard' Classroom Structure

The "standard" structure for most classrooms historically aligns students in rows facing the front of the room. Instructors positioned at the front, displaying their work on a large screen or projector. This design poses critical challenges to an instructor's ability to present information, identify issues, and engage with a problem once it occurs.

Due to the technical nature of such classes, it is extremely important to present students with highly detailed information; especially when providing examples in which syntax is crucial and where students must be able to identify clearly what is taking place. The standard classroom model maintains challenges for creating this shared student experience. Students in the back are often hindered by their inability to see displayed material. One remedy is to "zoom in" on pertinent work, but such displays can be difficult to manage and hinder the ability to portray large concepts. Inevitably, some students struggle to keep pace with the instructor.

As any technical instructor can attest, it is imperative to quickly identify students who become desynchronized with the class material. Even the slightest misstep can critically derail a student and prohibit their ability to continue with the instruction. Ideally, students would

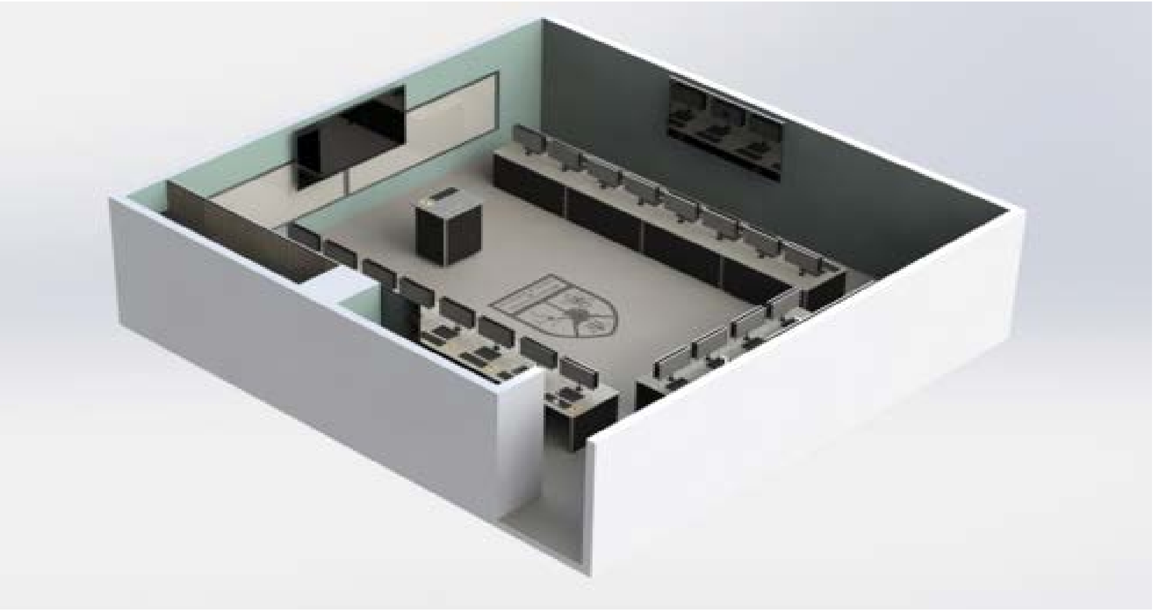

Figure 2: A CAD rendering of the new West Point D/PaNE CIF. All student monitors are mirrored towards the instructors so that student progress can be constantly assessed.

immediately self-identify to the instructor when this occurs, but too often they remain silent. As a result, they are rapidly outpaced by the class and become hopelessly lost. Instructors must conduct regular individual checks on student progress.

Unfortunately, the standard classroom offers no single vantage point to view all workstations, forcing the instructor to constantly pause the lesson and circulate the classroom seeking lost students. In the event an issue is discovered, the instructor must maneuver through cramped rows to arrive at the student's desk and address the problem. The rest of the class is forced to wait as the instructor parses through the student's work to resolve the issue. Any lessons learned are confined solely to the student and instructor and an educational opportunity is missed. By this time, minds begin to wander with some giving in to on-screen distractions. The instructor is left trying to reestablish control and continue class.

Too often this is the scene played out across technical classrooms throughout the country. But with a targeted redesign of the technical learning space, it is possible to mitigate, if not eliminate, most of these issues.

The Optimized Technical Classroom

Spearheaded by Dr. Kenneth Allen and LTC Ronald Hasz, West Point's D/PaNE has spent two years developing a better design for a technical computing classroom. These ideas were built upon earlier concepts. During a Fortran class at the Air Force Institute of Technology in 2001, Dr. Kirk Mathews told then CPT Ron Hasz of a concept for optimizing the computer instruction classroom. Dr. Allen and LTC Hasz worked with his suggestion to design this solution. Furthermore, the basic concept offers scalable solutions for a variety of institutions to target the issues of a standard classroom structure.

The most crucial aspect of the Optimized Technical Classroom (OTC) is the physical layout of the space. Unlike a standard classroom, students are positioned in a U-shape facing inwards. In an OTC, each workstation is equipped

Figure 3: Dr. Ken Allen teaching computation design in the West Point D/PaNE CIF.

with a standalone computer and dual monitor, one of which faces the instructor in the middle of the room. Similar results could be achieved by simply using center-facing monitors that duplicate student laptop displays but having more dedicated powerful computers that are set up to run the relevant software is preferable. The inwards-facing monitors enable the instructor to continually assess student progress and immediately engage in the event a student falls behind. As an added benefit, it is much easier to maintain student focus since the instructor is always aware if a student becomes distracted by other computer functions.

The second essential characteristic of the OTC is the ability to control the presentation of information. During a class period under the standard model, students must constantly adjust their attention between their work, the instructor, and any examples. With the use of Creston hardware and software, instructors can seamlessly direct the viewing content of each student. If the instructor wants to call attention to a specific student, they simply press a button and mirror their screen to all monitors in the room. Such actions are especially helpful when addressing several students who are struggling with the same issue. Through this "pushed" content, instructors can better manage the content is viewed by students.

Other considerations of the OTC, while not essential, enhance the student experience by providing a clean and safe learning environment. A raised floor and false wall protect hardware, prevent tripping hazards, and improve the aesthetics of the room. Large high-definition monitors afford students unobscured observation of teaching materials. The overall appearance is streamlined to provide a crisp, professional learning environment for students to thrive.

Incorporating virtual machines and external collaboration space into the OTC provides additional benefits. Most of the technical programs used are computationally expensive and rapidly outpace the processing power of student laptops. With virtual machines, students can access their work and powerful computers through VPN both in and out of class. This also enables the use of external collaboration spaces.

While the OTC is designed to promote in-class learning, the linear desk structure may hinder group activities. For technical computing, collaboration spaces are suboptimal for teaching, and teaching spaces are often suboptimal for collaboration. Pairing an OTC with a dedicated collaboration space using virtual machines allows students to thrive in both settings.

Impact

The D/PaNE CIF has been used to teach three semesters of undergraduate computational design, which entails the use of radiation transport codes and CAD software. "Without a doubt, I can say that I can move more quickly through the material now than in years past. Cadets aren't getting stuck with a syntax error and falling behind," Dr. Allen reports.

Other West Point departments have taken notice of the new facility, and several have used it to maximize learning. CPT Nathaniel Sheehan of the Department of Geography and Environmental Engineering recently held his Physical and Chemical Treatment Processes class in the CIF, where he taught the use of SolidWorks. "The dual-monitors were great – I could see anybody falling behind or having a novel issue. In those instances, I could bring that cadet's monitor up to either fix, troubleshoot, or show the class. I appreciated this experience so much I recommended the use of this facility to the other course directors I know, including our courses which teach Google Sketchup to non-engineer majors."

The West Point D/PaNE Computer Instructional Facility represents an improvement in the pedagogy of technical computing over traditional computer laboratories. There is a growing need within the nuclear and CWMD community for engineers and specialists with the skills to implement new reactor designs and integrate chemical, biological, nuclear, and radiological effects into modeling among other complex tasks. To train personnel on modeling and analysis tools, instructors must incorporate sophisticated software and applications into their programs. We encourage institutions to utilize the Optimized Technical Classroom to maximize learning.

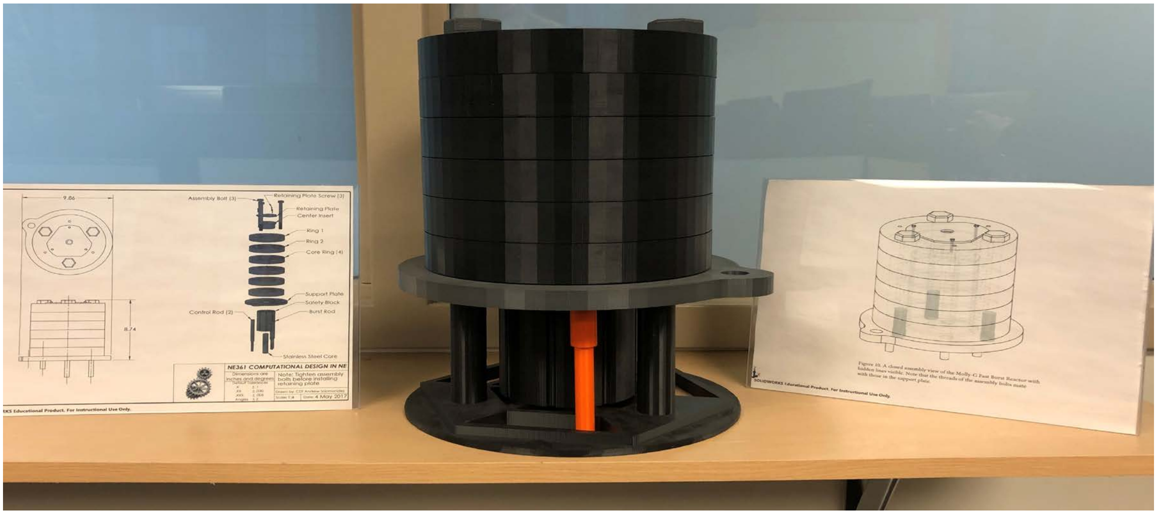

Figure 3: A student-created 3-D printed CAD replica of the White Sands Missile Range Pulsed Reactor from an Advanced Computation Design project. The CIF improves student experience in technical computing classes.

White Sands Missile Range:

The Nation's Bedrock for Nuclear Weapon Effects Test Capability

MAJ Andrew Lerch
Office of the Chief of Space Operations

Since the 1950s, White Sands Missile Range (WSMR) has been the epicenter for developmental testing and demonstrating some of the Nation's most significant technological innovations. The first nuclear weapon was successfully detonated at what is now WSMR in 1945 and the origins of the space program developed from testing advanced rocketry there. Currently, WSMR is the home for research, development, test, and evaluation of critical Department of Defense (DoD) programs in fields such as aerospace, kinetic weapon systems, directed energy, telemetry, and information technology. WSMR also possesses DoD's and the Nation's largest nuclear weapon effects test infrastructure. These capabilities are imperative for certifying DoD mission critical system survivability to air blast, thermal, radiation, and electromagnetic pulse environments that could be present on the battlefield. The nuclear weapon effects test facilities on WSMR are a national treasure.

Grouped under WSMR's Survivability, Vulnerability, and Assessments Directorate (SVAD), the nuclear weapon effects test facilities have been operating continuously and reliably since the early days of the Cold War. SVAD capabilities include air blast, electromagnetic, and thermal, ionizing, and non-ionizing radiation simulators.

SVAD is staffed by 103 government employees and 86 contractor personnel responsible for conducting more than 1200 test missions per year. Customers include the Army, Navy, Air Force, other DoD agencies, the Department of Energy, the National Aeronautics and Space Administration, allied nations, and industry. Many of SVAD's facilities serve Joint testing needs and are designated as a part of the DoD Major Range and Test Facility Base, which assures sustainment funding and long term efficacy. SVAD possesses several unique facilities: the Fast Burst Reactor (FBR), the Large Blast Thermal Simulator (LBTS), and the Advanced Fast Electromagnetic Pulse Simulator (AFEMPS). These three facilities are the only of their kind in the Nation.

The FBR is the Nation's only facility capable of testing systems, subsystems, and components on the effects of prompt fission neutrons at high fluence levels. The FBR began operations in 1964

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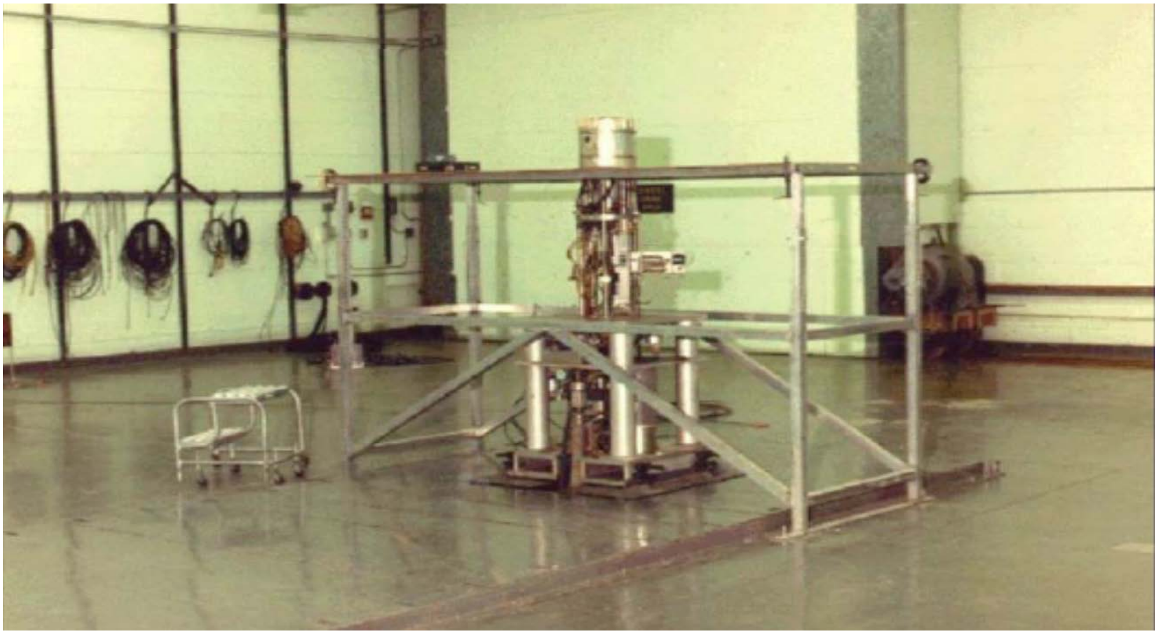

Figure 1: Fast Burst Reactor Facility at White Sands Missile Range

and has since conducted more than 20,000 test events. The reactor operates in pulsed and steady-state modes allowing for both dose rate and total dose testing. Additionally, a flash x-ray device provides the capability to test combined non-ionizing and ionizing radiation environments, which offers increased test fidelity.

New uranium fuel elements for the FBR are currently being manufactured to ensure that the reactor will continue to meet testing demands over the coming decades. Nuclear Triad modernization, ballistic missile defense, space system development, and hardness maintenance/hardness surveillance programs all rely on the FBR. SVAD anticipates that the facility will be fully subscribed for the next decade.

Another unique SVAD facility is the LBTS, located in the northern section of WSMR. Completed in 1994, the LBTS is the only facility in the world that can test systems to combined air blast and nuclear weapon thermal radiation environments. The LBTS can replicate weapon yields up to 600 kilotons and consists of a test volume that can accommodate full scale vehicle systems and scaled structures.

The LBTS was used to certify systems such as the M1 Abrams Family of Vehicles and the M2 Bradley Family of Vehicles to nuclear air blast environments. It was also used to examine the survivability of building materials against conventional explosives. The LBTS was "mothballed" in 2012, but in 2015 the Defense Threat Reduction Agency initiated a project to refurbish it and bring it back into operation. A demonstration of the revitalized LBTS air blast capability occurred in August 2017. Efforts are ongoing to reestablish the thermal capability, which consists of eight inverted rocket nozzles fueled by powdered aluminum and liquid oxygen. After of the restoration, the Army Test & Evaluation Command will operate the facility on behalf of DoD. Anticipated customers are the Army, the Air Force, the Department of Energy, and allied nations.

Figure 2: The Large Blast Thermal Simulator at White Sands Missile Range

FBR and LBTS are just two examples of WSMR's nuclear weapon effects test capabilities. SVAD consists of more than 60 different test facilities that all serve a distinct purpose to ensure that systems are survivable to hostile and ambient environments. As a result, combatant commanders can remain confident that mission critical systems will operate through those environments and accomplish their assigned missions. Moving forward, WSMR's challenge is to maintain its very competent and capable workforce. Nuclear weapon effects test and evaluation expertise is a niche skillset. For nuclear weapons effects, this is where the rubber meets the road!

WHITE SANDS MISSILE RANGE

BIRTHPLACE OF AMERICA'S MISSILE & SPACE ACTIVITY

Germany and Japan
Potential Nuclear Powers

MAJ Christopher Mihal
Air Force Institute of Technology

Germany and Japan currently do not need to develop nuclear weapons, yet they could see the need to do so if the current geopolitical order changes. Both are countries that are a "screwdriver's turn"[1] from having nuclear weapons, a state of being known as nuclear latency. Both countries have myriad reasons for not pursuing weapons, chief among them being protected by the extended deterrence offered by the United States. However, if either of the country's leaders perceive U.S. actions as erratic, they may determine that U.S. extended nuclear deterrence is no longer reliable. Were this to happen, a country feeling threatened by regional rivals could feasibly see the need for a nuclear arsenal. Already factions in both countries have made the case to do so.

Germany as a Nuclear Power

Christian Hacke, one of Germany's foremost political scientists, succinctly summed up the reasons why Germany's current defense posture needs revision:

> The foreseeable loss of the U.S. nuclear deterrent, the lack of a European nuclear deterrent, the erosion of Western institutions like NATO and the European Union, as well as Germany's inadequate defense culture call for a complete re-assessment of Germany's defense policy. This also begs the question: under which circumstances and at what cost could Europe's central country become a nuclear power?[2]

While extremely controversial, especially given Germany's signature to the 1954 Paris Agreements, where Germany pledged not to develop nuclear weapons,[3] their signature of the Nonproliferation Treaty (NPT), and Germany's historic reticence towards military build-ups since World War II, there are certainly reasons for Germany to reconsider its stance on possessing a nuclear arsenal. Although a relatively strong member of the NATO alliance, Germany has not reached the 2% of GDP spending goal NATO has in place for all of its militaries. Its 2024 military spending goal is only 1.5% of GDP.[4] There is little initiative for a significant expansion of the armed

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forces. Additionally, a large build-up would require considerable time and resources to adequately train and equip nuclear force. The status of the NATO alliance is fragile, Brexit, and a rising tide of Eurosceptic parties coming to power casts doubts on the efficacy and utility of the European Union (EU). Furthermore, unlike previous U.S. presidents, President Trump did not affirm Article 5, NATO's mutual aid clause, something that undoubtedly unnerved European members; it is debatable whether this was an intimidation tactic or deliberate omission.[5]

Were the EU and NATO alliance to dissolve, Germany would be surrounded by regional nuclear-capable powers: the United Kingdom, France, and Russia. While Germany enjoys cordial relations with both the UK and France – to the extent that France offered to "share" it's nuclear arsenal with Germany[6] – any disruption of the current geopolitical order could place Germany in the center of a conflict. Such states might not be willing to extend deterrence to Germany in the event of Russian adventurism or regional conflict. While extremely unlikely – Germany has only had to contend with a few small-scale, radical left-wing attacks in recent years from other EU states,[7] a nuclear arsenal would be an invaluable deterrence factor to prevent any sort of Russian or otherwise aggression towards Germany. Although an unlikely scenario – given the mercurial nature of European politicians lately, perhaps not completely improbable – France or the UK reverting to their traditional roles as Germany's adversary could lead Germany to develop a nuclear capability.

A nuclear deterrent would enable Germany to remain the preeminent power in continental Europe were NATO and/or the EU to collapse. Several prominent members of German society feel that Germany can no longer rely on U.S. protection or extended deterrence, as "the cumulative weight of bad faith and bad policy has collapsed trust."[8] Germany could conceivably decide that it must be self-reliant for defense, and turn the proverbial screwdriver to develop a nuclear arsenal. However, for Germany to do so is significantly less likely than the other state under consideration: Japan.

Japan as a Nuclear Power

Japan has a similar security situation to Germany, it has the expertise and resources to develop nuclear weapons but has so far chosen not to. It has long been Japanese policy that its most effective deterrent is the capability to become a nuclear power, but refraining from doing so keeps Japan in the spirit of the NPT.[9] Unlike Germany, however, Japan has two, potentially three, hostile nuclear powers in close proximity – North Korea, China, and Russia. South Korea is a historic rival with the potential of acquiring nuclear weapons. Japan has active territorial disagreements with Russia, China and the Koreas, any of which could lead to military conflict. Similarly, Japan also faces eroding trust in the U.S.'s policy of extended deterrence. President Trump has reportedly called the security treaty "unfair"[10] and stated that Japan should develop nuclear weapons for its defense since "it's going to happen anyway."[11]

Given the uncertainty regarding the U.S. commitment to defending Japan, particularly in light of recent North Korea missile tests, the decision to become a nuclear power is a possibility for Japan in the near future. As the only country to ever suffer a nuclear attack, Japan has a large segment of its population vociferously opposed to nuclear weapons. Yet with the fear of abandonment by the United States, Japan may undertake a nuclear weapons program. Much of Japan's defense policy already requires having a nuclear deterrent, currently provided by the U.S.[12] Despite being a taboo subject, Prime Minister hopeful Shigeru Ishiba has stated publicly that Japan should have the freedom to build nuclear weapons.[13]

Japanese relations with its nearest neighbors have been strained, particularly with the unabashed nationalism of Prime Minister Shinzo Abe coupled with the collective memory of Japanese atrocities during World War II. Japan is wary of China's growing political and military power. While an invasion is extreme, Japan could develop a nuclear capability to deter that possibility. Japan could use nuclear weapons for both deterrence and compellence. For instance it could force South Korean forces off of the Liancourt Rocks.

Already within Japan there is an ongoing debate about removing the "pacifism clause" in its constitution, forbidding offensive actions or the development of certain weapons.[14] Though the debate is currently limited to conventional forces, it would be but one more step for it to include nuclear weapons as well.

Conclusion

Japan and Germany currently do not need to develop nuclear weapons. Both countries are protected by U.S. extended deterrence, and both also have large segments of their populations resolutely opposed to the development and acquisition of nuclear weapons. Both also have the specter of their past reputations of imperialism and bloodshed, which their current leaders and citizens would like to move on from. Both nations see comfort in the current world order. While Germany and Japan have regional rivals in Russia and China, neither state sees open conflict as likely. However, given the increasingly unpredictable nature of North Korea and the uncertainty of the future of the EU and NATO alliances, the current world order could be radically altered in the near future. To prepare for an uncertain future, Germany or Japan may decide the best course of action for national survival is to "go it alone." Growing segments of the population in both countries feel they can no longer rely on U.S. protection, something that has been a given for decades. The national security granted by nuclear weapons is unparalleled. Both Germany and Japan are just steps away from acquiring nuclear weapons. The world hopes that events do not force them to take that last step and irrevocably cross a threshold that may be impossible to return from.

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CBRN Vignette 20-1
"Contaminated Convoy"

LTC Daniel Laurelli
United States Army Nuclear and Countering WMD Agency

This CBRN vignette is part of an ongoing series of scenarios developed as a training tool for decision makers at all levels – tactical to strategic. The goal is to foster thought, discussion and to support training. Readers are encouraged to send possible solutions to the Countering Weapons of Mass Destruction Journal as a means of interaction with the CBRN community. The author's solution, along with selected readers' solutions, will be published in future journal issues.

Background

At the request of the Transican government, the U.S. deployed Joint Task Force (JTF) Protector to assist in stabilizing the nation of Transia. The Transican military with assistance of national police force and local militias, recently prevailed from a violent civil war, culminating in a major force-on-force engagement. As a result, the nation's military and infrastructure was heavily damaged. JTF Protector was deployed to provide humanitarian assistance to civilian population, and military assistance to the battered Transican military and local pro-government militias.

Situation You are the Commander of the 55th Chemical Company (Combat Support – CS) in support of JTF Protector. Due to the high demand for convoys to government friendly population centers, you were placed in charge of Convoy 55 to resupply the village of Trabók using Main Supply Route (MSR) Red. It is critical the water and cargo reaches its destination.

Friendly Forces The three Decon Platoons were detached from the 55th Chemical Company (CS) to support to Logistics Base (LOGBASE) Wolverine located west of Figure 1 (Convoy 55 Map and Overlay). For additional security above the two operational Nuclear, Biological and Chemical Reconnaissance Vehicle (NBCRV) Strykers, the 5th Infantry Division (ID) attached two infantry configured Strikers, without their dismounts. For transporting supplies a cargo truck platoon consisting of 8 cargo Heavy Expanded Mobility Tactical Truck (HEMTT) and a water truck platoon

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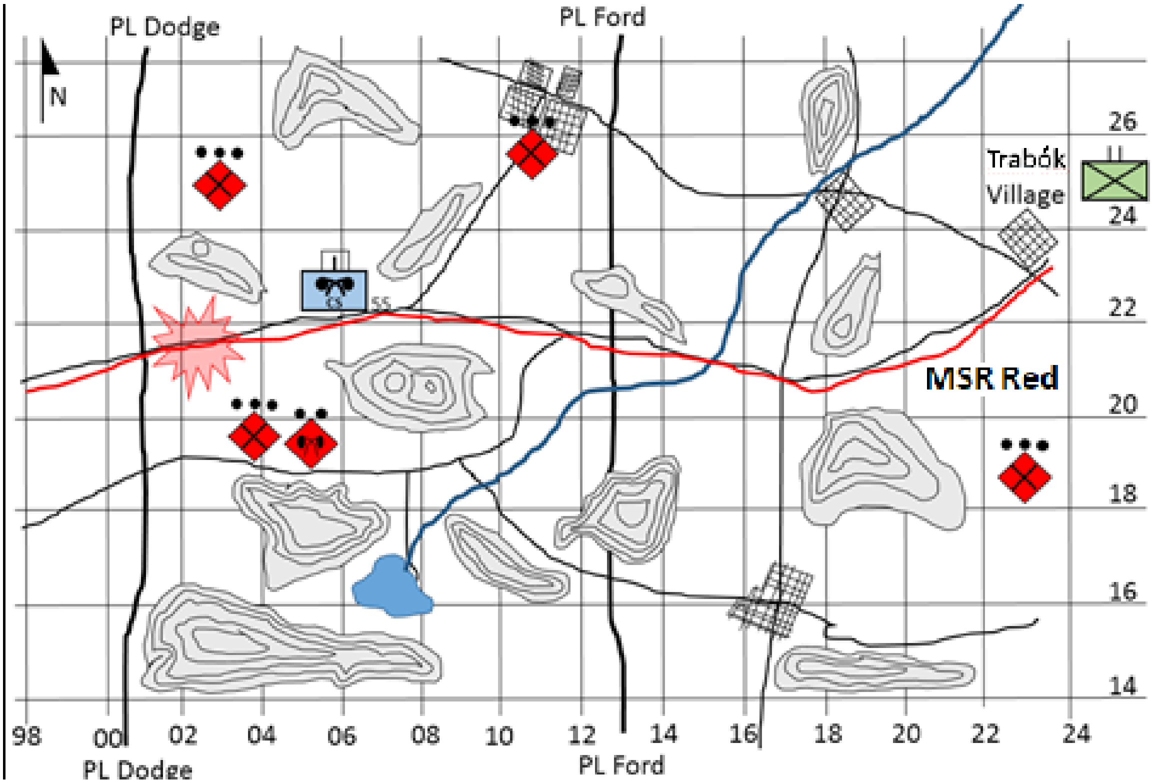
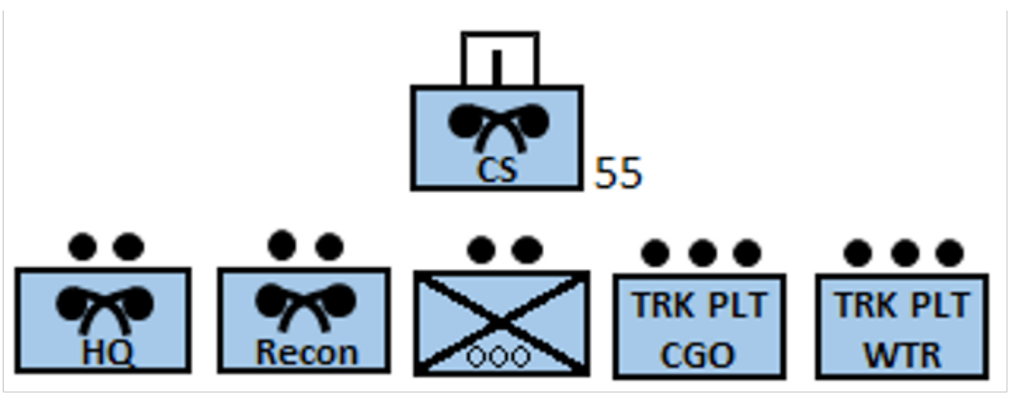


Figure 1: Convoy 55 Map and Overlay



Element	Vehicle Type	Amount	Personnel
HQ	HMMWV (CMD)	2	4
5th ID	Stryker (Security)	2	8
Co	Fuel Truck (LTV)	1	2
Co	Wrecker (HEMTT)	1	2
Recon TM	Stryker NBCRV	2	6
TRK PLT 1	Transport Truck (HEMTT 2,500gal)	8	24
TRK PLT 2	Cargo Truck (HEMTT)	8	24
Total		24	70

Figure 2: Convoy 55 Organization

consisting of 8 potable water HEMTT tankers. The local militia Transian (pro-government) Infantry Battalion is securing the village, but is not well-trained or supplied. The village is under harassment from insurgence cells.

Enemy Forces JTF Protector Area of Responsibility (AOR) of Transia has significant insurgent elements (up to platoon size). As a result of the loss of the force-on force battle, some elements of the opposing force has taken to insurgency tactics. They are armed with small arms, RPGs, and light trucks. These insurgent elements operate throughout the countryside reducing freedom of movement between population centers. The insurgent platoons increase their patrols at night. Unconfirmed intelligence reports (low confidence) state some insurgence elements have acquired a small stockpile of un-weaponized (bulk) HD mustard agent in another Division's AOR. The JTF Protector S-2 (Intelligence Section) determined if reports are true, the insurgency lacks transportation assets to move it into the 5th ID AOR or the CBRN expertise to employ it.

Weather It is a cold February in Transia with a high of 50 degrees F. The sun sets at 1730 and projected nighttime low of 40 degrees F with possibility of light rains after midnight.

Scenario

Convoy 55 departed LOGBASE Wolverine at 0600 (local) to resupply the village of Trabók, and the local infantry Battalion providing security. At approximately 1400, soldiers in the convoy started to report unusual smells, irritation on exposed skin, scratchy throats and burning in the eyes. The convoy halts just north of MSR Red, coordinates 045221 and takes up a perimeter defense. The NBCRVs conduct testing the vehicles and identify HD mustard agent mixed with the mud. It appears insurgent elements poured the agent across MSR Red to contaminate vehicles; which are typically either US or Transian government vehicles. The undercarriages and tires of all convoy vehicles are contaminated. Convoy personnel have their protective masks, but only one set of Mission Oriented Protective Posture (MOPP) gear. No friendly forces are available until the next day to provide assistance. The two 5th ID Stryker vehicles have just identified at least two insurgency units (squad level or larger) in the area. Both elements are staying under cover but using the mountains to the north and south of MSR Red to maneuver closer to the stopped convoy. There is one steady waterway (river) flowing to the Northeast in the AOR, and it is the only drinkable source for several towns and villages downstream. Contaminating this river will affect hundreds of Transians and present a significant environmental and political problem for the weakened Transian government and US in attempting to combat the insurgency.

Requirement

After reviewing the situation, outline your issues and write a FRAGO for Convoy 55. Readers wanting to submit their solutions to the scenario should provide the Fragmentary Order to USANCA care of daniel.p.laurelli.mil@mail.mil.

CBRN Vignette 19-1
"Back to Basics" - Author's Solution

LTC Daniel Laurelli
United States Army Nuclear and Countering WMD Agency

Vignette 19-1 Requirement

Your Weapons of Mass Destruction Coordination Element (WMD CE) was tasked to develop a CBRN training plan for Brigadier General Sosabowski to prepare his division. After reviewing the situation, outline your plan for preparing the 55th Light Armor Division (LAD) deployment in 6-8 weeks.

Situation

You are the CBRN Officer in charge of a WMD CE deployed to the threatened nation of Transia. The WMD CE was placed under operational control (OPCON) of the 55th LAD, Divisional Headquarters. The CJTF-Freedom Protection Warfighter Forum (WfF) just completed a CBRN assessment of the 55th LAD from Kemalia and commanded by Major General Sosabowski. The CJTF-Freedom Protection WfF determined the unit is completely deficient in CBRN training and equipment.

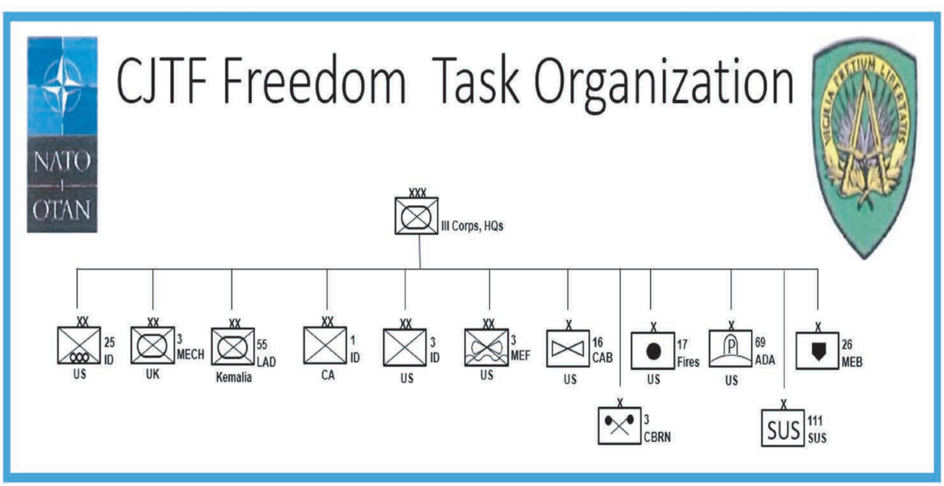


Figure 1: CJTF Freedom Task Organization

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Background

The nation of Kemalia is a former satellite nation to the Soviet Union and was recently granted membership to NATO. Kemalia spent many years rebuilding its nation after the fall of the Soviet Union, which left it in economic ruin. In the last five years Kemalia's economy improved enough to increase its national budget, which included revitalization of its military forces. In order to demonstrate Kemalia's new alliance and military prowess, it volunteered to support NATO missions. With the crisis in Transia, Kemalia deployed their premier Combat Element, the 55th Light Armor Division (LAD). The 55th LAD was assigned to CJTF-Freedom (Figure 1). CJTF-Freedom is composed of the U.S. III Corps Headquarters along with U.S. and other NATO units (Figure 1). U.S. European Command (USEUCOM) is CJTF-Freedom's higher headquarters for defending the country of Transia from its neighbor Donovia. The 55th LAD is in Tactical Assemble Area (TAA) Hedgehog scheduled for front line tour of duty in the next 6-8 weeks. The CJTF-Freedom WfF coordinated with US logistics planned to provide sufficient basic CBRN equipment for the division to include joint service lightweight integrated suit technology (JSLIST), Protective Masks (M24, M40, M42, M45 and M48), M41 Protection Assessment Test System (PATS), Improved Chemical Agent Monitor (ICAMs), M22 Automatic Chemical Agent Detection Alarms (ACADAs), M8 Chemical Agent Detector Paper, M9 Chemical Agent Detector Paper, M265A2 Chemical Agent Detector Kits, M291/295 Decontamination Kits, and M285A1s) for the 3,500 soldiers in the 55th LAD.

55th LAD

The 55th LAD is well-led, highly trained, and motivated, but its equipment is dated. The division is equipped with refurbished French and United Kingdom hardware (Figure 2). The 3,500 soldier division was composed of a scout company (Scorpion – scout vehicles), one mechanized infantry brigade (Scorpion – Infantry Fighting Vehicle (IFV)), two armored bridges (AMX main battle tanks (MBT)), a self-propelled artillery battalion (105mm), a support battalion, chemical company, engineer company and an air defense artillery company. While the 55th LAD does have an organic CBRN Company, it is more of a firefighting element equipped with bunker gear and 8 Tactical Firetrucks.

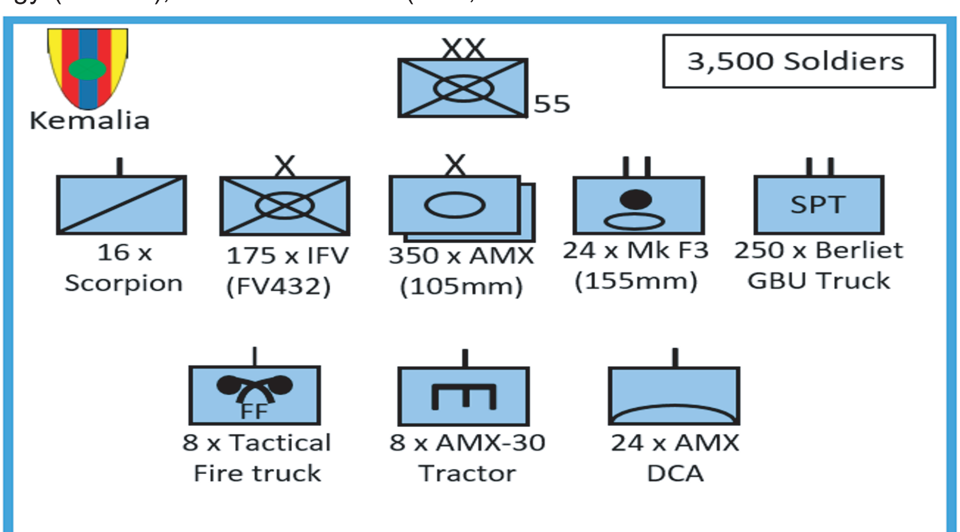

Figure 2: 55th Light Armor Division (LAD)

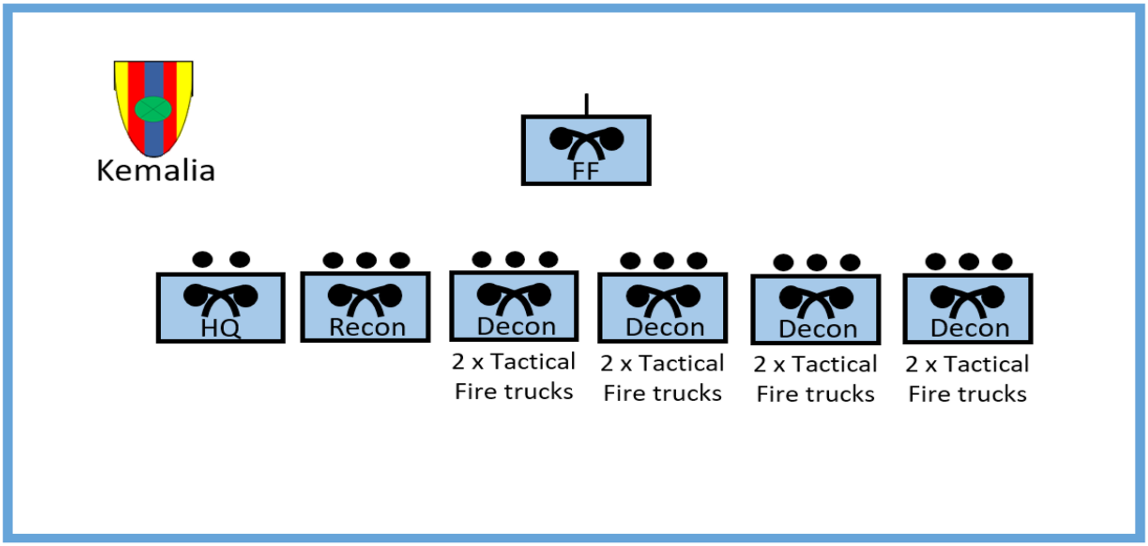

Figure 3: 55th LAD Reorganized Chemical Company

Leadership

Brigadier General Sosabowski is experienced and competent soldier commanding 55th LAD. He demands his officers and NCOs are professional and competent.

Enemy Forces

The nation of Donovia is preparing to invade its neighbor of Tranisa. Donovia is military is a credible threat to any modern military force. Donovian ground units are well-trained in operating in a chemical contaminated area. The Donovian army has significant Chemical offensive artillery capability, including tear gas, phosphorous, and nerve agents. Donovia concept of operations is to conduct conventional and unconventional (Chemical) artillery attacks prior to initiating offensive operations.

Solution

Mission The WMD CE conducts CBRN training in TAA Hedgehog with the 55th LAD to ensure the Division can successfully operate in a CBRN environment within the next 6 weeks, prior to the unit's upcoming deployment.

Intent The intent is to train the entire 55th LAD in basic CBRN training tasks, train the Chemical Company on CBRN reconnaissance and surveillance, decontamination operations, and leadership in CBRN operations prior to the Brigade deploying in 6-8 weeks.

Task to subordinate units

Task 1 Train the 55th LAD in basic CBRN tasks.
Purpose Prepare 55th LAD for operating in and CBRN environment.

Task 2 Train the 55th LAD Chemical Company to conduct CBRN reconnaissance and surveillance, and decontamination operations.
Purpose Prepare the 55th LAD Chemical Company for providing CBRN reconnaissance and surveillance, and decontamination support.

Task 3 Train the 55th LAD Scout Company to conduct CBRN reconnaissance and surveillance operations.
Purpose Prepare the 55th LAD Scout Company for providing CBRN reconnaissance and surveillance support.

Training Schedule

Week 1

- Have a chemical personnel designated for each battalion, Brigade and at Division Headquarters.
- Train Brigade, Battalion, and Company Officers, and senior NCOs in basic (soldier tasks and unit) CBRN tasks (train the trainer). Have a chemical personnel designated for each battalion, brigade and at the division headquarters.
- Train Scout Company on CBRN reconnaissance and surveillance.
- Re-organization of the 55th LAD Chemical Company into a five platoon company with one CBRN reconnaissance and surveillance and four decontamination platoons. Each decontamination platoon is based on two tactical fire trucks per platoon (decontamination systems). (Figure 3 – 55th LAD Reorganized Chemical Company).
- Train the 55th LAD Chemical Company on CBRN reconnaissance and surveillance, and decontamination operations.

Week 2

- Assist in training for each company with soldier tasks and unit) CBRN tasks.
- Field train the 55th LAD Chemical Company on CBRN reconnaissance and surveillance, and decontamination operations.
- Train the 55th LAD Scout Company on CBRN reconnaissance and surveillance.
- Train Division and Brigade staff.

Week 3

- Supervise Lane training for squads.
- Conduct ranges with 55th LAD soldiers in MOPP gear.
- Conduct drivers training will in MOPP.
- Train the 55th LAD Scout Company on CBRN reconnaissance and surveillance.

Week 4

- Supervise Lane training for platoons.
- FTX the 55th LAD Chemical Company and Scout Company on CBRN reconnaissance and surveillance, and decontamination operations.

Week 5

- Supervise Lane training for companies.
- Conduct Field Training Exercise (FTX) with the 55th LAD Chemical Company and Scout Company on CBRN reconnaissance and surveillance, and decontamination operations.

Week 6

- Conduct Brigade level CBRN FTX.

CWMD Policy and Strategy
Distant Education Opportunity

USAF Center for Strategic Deterrence Studies

The USAF Center for Strategic Deterrence Studies has developed an elective to educate interested participants on the development and execution of U.S. counter-WMD policy and strategy. This course is designed for Air Force service members (military and civilian), although other USG personnel may also benefit from taking this course. The purpose of this course is to develop experienced CWMD analysts to work in staff and leadership positions at major commands, defense agencies, and Headquarters Air Force. Future iterations of this course may include focused modules for Army participants.

The course will be offered at least twice a year – April through June, and September through December – and will require about 20 hours (or more) for completion. This is an asynchronous course, meaning the student will log into the Canvas learning management system and take instruction at their own pace, without simultaneous instructor involvement. Ten lessons will be provided over a ten-week period.

The course topics include:

- Introduction to countering WMD (WMD definitions)
- WMD threat overview
- National guidance on WMD issues
- DoD counter-WMD plans and policy
- Arms control and nonproliferation
- Counter-WMD during major combat operations
- Counter-WMD during irregular warfare operations
- Counter-WMD during homeland security operations
- Future roles and issues in countering WMD

Student deliverables include participation on discussion boards with other students and a research paper (2500-3000 words) due by the end of the course. This is an UNCLASSIFIED course and all discussions/responses must be unclassified. Upon completion of all deliverables, a certificate of accomplishment will be issued at the end of the course. Syllabus is available upon request.

To participate in the program, please contact the instructor Al Mauroni at albert.mauroni.1@us.af.mil and the registrar Rachael Croom at rachael.croom.ctr@us.af.mil.

Conference Schedules

Note: availability may change due to the COVID-19 outbreak.

International Hazardous Material Response Teams Conference 2020

June 4 – 7, 2020 Baltimore, MD

IAFC's Hazmat Conference provides the latest classroom, hands-on, and field trip-based training on what's new in HAZMAT, covering all aspects of HAZMAT, including transportation, safety, WMD, gear, terrorism, mass decontamination, bioterrorism and more. The HAZMAT exhibit floor includes outdoor demonstrations of hazardous materials gear and equipment.

https://www.iafc.org/events/hazmat-conf

2020 BIO International Convention

June 8 – 11, 2020 San Diego, CA

The BIO International Convention is hosted by the Biotechnology Innovation Organization (BIO). BIO represents more than 1,100 biotechnology companies, academic institutions, state biotechnology centers, and related organizations across the United States and in more than 30 other nations. BIO members are involved in the research and development of innovative healthcare, agricultural, industrial, and environmental biotechnology products.

https://www.bio.org/events/bio-international-convention/event-overview

Event available digitally. Register at:

https://www.bio.org/events/bio-digital

NDIA CBRN Defense Conference & Exhibition

July 27 – 29, 2002 Wilmington, DE

CBRN Defense Conference & Exhibition is a premier international annual conference related to defense industry and organized by National Defense Industrial Association.

https://www.ndia.org/

2020 Global Explosive Ordinance Disposal (EOD) Symposium and Exhibition

August 11 – 13 2020 Virginia Beach, VA

Global EOD Symposium is a premier international annual symposium related to defense industry and organized by National Defense Industrial Association. Update the EOD community on the latest policy decisions and technology within this field.

https://www.ndia.org/

CWMD Coordination Conference

September, 2020 Ft. Belvoir, VA

This annual conference brings together hundreds of CWMD experts from across Combatant Commands, OSD, the Joint Staff, Military Services, USG agencies, and key international partners to advance progress on CWMD global campaign tasks and issues.

NCT USA 2020

September 1 – 3, 2020 Edgewood, MD

NCT USA 2020 brings together high-level decision-makers, local & federal first responders as well as industry leaders in the fields of CBRNe, C-IED, and EOD. The event will include a conference, exhibition, and the 6th edition of the NCT PRO Trainings. The NCT PRO Trainings increase interoperability of responders and introduce them to the latest CBRNe, C-IED, and EOD technologies.
http://nct-usa.com/

Precision Strike Technology Symposium (PSTS-20)

October 20 – 22, 2020 Laurel, MD

The Precision Strike Technical Symposium (PSTS) is a SECRET//NOFORN event that will focus on the tactical and technological challenges faced by our warfighters and the supporting industrial base. PSTS topics include current warfighting challenges and environment, pioneering technologies from the DoD Service and National laboratories, novel strategies and concepts from Industry thought leaders, and a range of other time-relevant subjects presented by a broad selection of organizations.
https://www.precisionstrike.org/events-listing/2020/10/20/1pst-precision-strike-technology-symposium

2020 ABSA 63rd Annual Biosafety and Biosecurity Conference

Oct 31 – Nov 5, 2020 Pheonix, Arizona

The 63rd Annual Biosafety and Biosecurity Conference will host three full days of intensive professional development courses to educate and inspire. During this conference state-of-the-art keynotes, papers, and panels highlighting best practices and hands-on skills crucial for today's biosafety and biosecurity professionals will be presented. Exhibits showcasing the latest in laboratory biosafety and biosecurity products and services will be on display. The event will provide invaluable networking opportunities to share and learn from other biosafety and biosecurity professionals.
https://absaconference.org/

13th CBRNe Convergence

November 2 – 4, 2020 Boston, MA

This three day event hosts two pre-conference workshops, a two-day streamed conference, the largest exhibition of CBRN equipment in the US in 2020, and a dynamic demonstration. The two workshops are 'High Threat Exercise' and 'Health response to the Novichok poisoning.' The first is run by the team from the Wales Extremism and Counter Terrorism Unit and will look at some real cases and innovative ways of managing them.
https://cbrneworld.com/events/cbrne-convergence-boston

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. 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, nonsensitive, 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/.

The *Countering WMD Journal* is published twice a year: Summer/Fall (article deadline is 15 September) and Winter/Spring (article deadline is 15 March). Send submissions via email to usarmy.belvoir.hqda-dcs-g-3-5-7.mbx.usanca-proponency-division@mail.mil, or as a Microsoft Word document on a CD via mail, to: Editor, CWMD Journal, 5915 16th Street, Building 238, Fort Belvoir, VA 22060-5514.

You can get more information about submitting an article to the *Countering WMD Journal*, download an article format, or view and download digital versions of the *Countering WMD Journal* at our website http://www.belvoir.army.mil/usanca/.

U.S. ARMY NUCLEAR AND CWMD AGENCY

Fort Belvoir, Virginia