Strategic Plan 2016 - 2025
Science & Technology
Joint Non-Lethal Weapons Program

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> "Whenever and wherever we use force, we will do so in a way that reflects our values and strengthens our legitimacy." —*2015 National Security Strategy*

The Nation's Joint Forces are tasked to execute missions across the globe, spanning the full range of military operations, from peacekeeping and humanitarian assistance to major combat campaigns. The current toolkit of Non-Lethal Weapons (NLW), backed by the Joint Non-Lethal Weapons Program (JNLWP) and the Services, reinforces these missions by enabling commanders to tailor their responses to situations by providing them with a set of escalation-of-force options between 'shouting and shooting.' Across today's range of military operations, these non-lethal capabilities protect the force, enhance adaptability and promote strategic objectives.

As we look towards the future, the military's breadth of tasking will remain, but its perspective will shift as it encounters new, austere operating environments and an increasingly rapid pace of technological change. Strategic drivers, to include operations in megacities and in dispersed battlefields, and technological advances in directed energy weapons and unmanned systems, will challenge the way the Joint Force approaches future military operations. These developments will require new non-lethal capabilities to address threats in an era of complex operational paradigms and reduced budgets.

The purpose of this JNLWP Science and Technology (S&T) Strategic Plan (JSTSP) is to articulate a direction for future JNLWP S&T efforts for addressing these new concerns and retain sufficient flexibility and freedom of action to meet emerging challenges. The plan is built on a thorough review and thoughtful consideration of National and Military strategic guidance, coupled with Service level strategy and policy documents. From this lens, the JSTSP outlines a series of S&T objectives, or STOs, that are the core of the strategic plan and are focused on capabilities for the 2025 timeframe with a progressive plan of technology development.

The STOs themselves are based on capability gaps and enabling technologies that are expected to be important to the future warfighter and are based on strategic guidance and interpretation of the future operating environment. From this analysis, the JNLWP S&T Program has highlighted significant enabling technology opportunities in directed energy (DE) to address non-lethal capability gaps and emerging requirements. Although DE currently stands as the most promising avenue for a leap-ahead technological capability, the JSTSP also highlights additional enabling investment objectives in human effects research, conducted energy weapons (human electro-muscular incapacitation), and sound and light that will advance the state of the art for NLWs and provide improved capability to the Joint Force.

The STOs in the JSTSP are not exclusive of all S&T funding within the JNLWP, but instead are the program's strategic prioritization for S&T investment to ensure needed capabilities are available to the future warfighter. The JNLWP S&T Program maintains the flexibility to address capability objectives through novel or innovative ideas from within and external to the Department of Defense (DOD) Research and Engineering (R&E) enterprise.

The JNLWP S&T Strategic Plan and associated process serves as a complement to Service S&T plans and the wider DOD NLW Enterprise and acts as a guidepost to communicate the goals of the Joint NLW Program S&T investment. In the end, this increased collaboration and communication will help address future operational paradigms the Joint Force will face and lead to innovative and game-changing ideas in the DOD's NLW portfolio.

Feedback is encouraged at any time from stakeholders internal and external to the NLW Enterprise. Please provide that feedback to my point of contact, Ms. Alicia Owsiak, JNLWP S&T Program Manager, at alicia.owsiak@usmc.mil.

Colonel Michael A. Coolican
Director,
Joint Non-Lethal Weapons Directorate

1.0 INTRODUCTION

"…control of escalation is becoming more difficult and more important…"
—2015 National Military Strategy

Twenty years since the founding of the DOD Non-Lethal Weapons (NLW) Program, the United States military faces global responsibilities in an increasingly interconnected yet uncertain world. In this environment of rapid technological change and challenges to the status-quo, the Joint Force will continue to be tasked to subdue emerging threats and respond to humanitarian crises alongside, if not among, civilian populations. To accomplish these tasks, warfighters require NLW capabilities to respond to potential threats between "shouting and shooting" and to control the escalation-of-force, while minimizing collateral damage — capabilities the Joint Non-Lethal Weapons Program (JNLWP) is investing in today.

DOD NLW Program Vision

Essential Elements:
A fully integrated non-lethal competency within each Service to complement lethal effects, enhance the Joint Force's adaptability, and support strategic objectives that include minimizing civilian casualties and reducing collateral damage

As part of this escalation-of-force capability, the Department of Defense (DOD) NLW Executive Agent has outlined the DOD NLW Program vision and charged the JNLWP to lead the Joint Force in conducting research and development (R&D) to enable "an integrated NLW competency." The JNLWP Science and Technology (S&T) Program contributes to the DOD NLW Program vision by investing in innovative technology and applied research to mitigate non-lethal effects capability gaps and reduce developmental risk. The JNLWP S&T Program's intent is to "Foster the ideation, maturation, and demonstration of innovative and compelling NLW technologies for the Joint Force through focused investment and collaboration internal and external to the DOD Research and Engineering (R&E) Enterprise."

This JNLWP S&T Strategic Plan (JSTSP) articulates a direction for future JNLWP S&T investment to spark innovation and cooperative research and development partnerships across industry, academia, and government.

JNLWP S&T Program Intent

Foster the ideation, maturation, and demonstration of innovative and compelling NLW technologies for the Joint Force through focused investment and collaboration internal and external to the DOD R&E Enterprise

To better promote communication and clarity of ideas for future NLW S&T efforts, this plan begins by outlining the strategic context of potential future operating environments and some of the unique aspects of NLW technology development. The JSTSP then defines a series of JNLWP Science and Technology Objectives (STOs) based on validated and emerging Joint Force requirements and shaped by future operating concepts. These STOs will act as guideposts for JNLWP S&T investment through 2025.

The JNLWP intends that the plan will be reviewed every two years, or as necessary, to refresh the STOs based on

technological advancements and evolving needs. This approach will enable the JNLWP S&T Program to remain on the cutting-edge of technology, while retaining alignment with new realities about emergent operations.

Figure 1: DOD NLW Program S&T and Development Activities

2.0 STRATEGIC PERSPECTIVE FOR NLW TECHNOLOGY DEVELOPMENT

NLWs as a Force Enabler

Individuals and groups in conflict have used non-lethal capabilities and actions throughout recorded history. Relatively simple cognitive and physical incentives designed to affect a person's behavior without imposing permanent harm, as well as actions to preserve infrastructure assets on the battlefield, have evolved over time to be described by labels such as 'show of force' or 'deterrence.' As warfare evolved, commanders increasingly used these non-lethal instruments as an option to control the escalation-of-force through graduated measures before, or instead of, taking lethal action. As the military and other instruments of national power have become more technologically advanced, so have the suite of non-lethal capabilities between 'shouting and shooting.'

Today, U.S. forces are required to execute missions spanning the full range of military operations, from stability operations, disaster response and humanitarian assistance to full-scale armed combat. NLWs enable commanders to tailor their responses to targets and situations across this continuum. The current NLW inventory expands our forces options in supporting mission objectives; however, as the military looks ahead to the coming decade, the shift to new operating environments and the rapid pace of technological change will require new NLW technologies to address capability gaps and threats from technologically evolving adversaries. Advancements in NLWs through scientific research and technological developments will enable these non-lethal effects to be realized in more effective and efficient ways.

The DOD Non-Lethal Weapons Program Vision calls for a fully integrated non-lethal competency within each Service[1] to complement lethal effects, to enhance the Joint Force's adaptability, and to support strategic objectives that include minimizing civilian casualties and reducing collateral damage. The program's mission is to serve as the Department's proponent to effectively identify, develop, test and evaluate, transition, field, and sustain integrated, relatively reversible, and scalable effects technologies and capabilities. The program also informs associated policies, doctrine, concepts, and training to provide timely solutions to current and future requirements across the range of military operations, as well as maximize mission effectiveness, and minimize risk to U.S. forces, coalition partners, civilians, and critical infrastructure.

[1] The Military Services are the Army, the Marine Corps, the Navy, the Air Force, and the Coast Guard. The term "Military Services" includes the Reserve Components, which include the Army and the Air National Guards of the United States

The Joint Non-Lethal Weapons Program

As outlined in DOD Directive 3000.03E, the Commandant of the Marine Corps (CMC) serves as the DOD Executive Agent (DOD EA) for the DOD NLW Program, which is inclusive of the JNLWP and Service-unique NLW programs. As shown in Figure 2, the Joint NLW Integrated Product Team advises the CMC while the Joint Non-Lethal Weapons Directorate (JNLWD), on behalf of the DOD EA, provides day-to-day management of the program, to include technical and programmatic planning and oversight of the JNLWP S&T Program. Responsibility for managing the JNLWP S&T Program's fiscal and technical performance is delegated to the JNLWP S&T Program Manager. The JNLWP S&T Program is focused on conducting research and on developing technology with broad applicability to address Joint and Service requirements in support of the overarching DOD NLW Program.

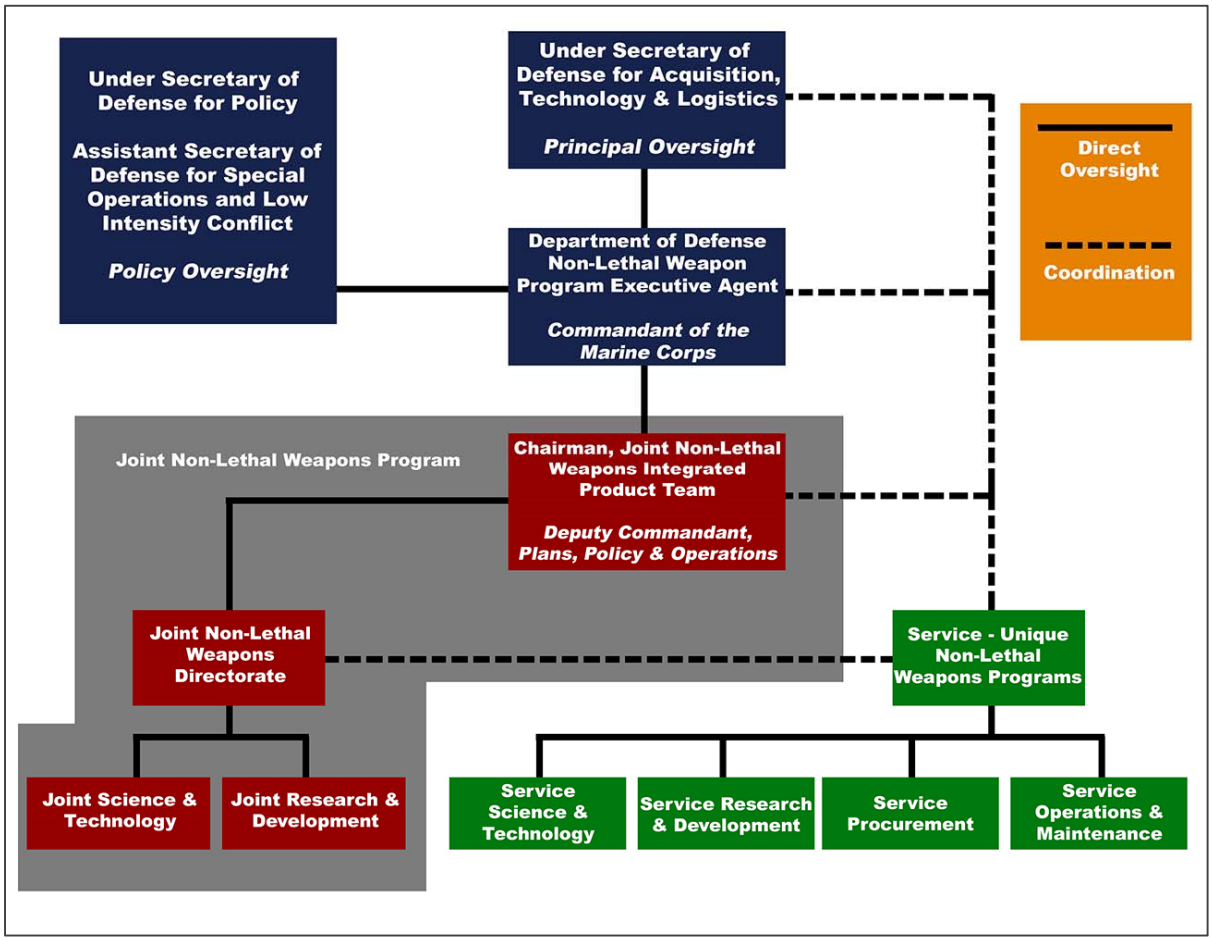

Figure 2: DOD NLW Program Organization

The JNLWP is appropriated via three Research, Development, Test and Evaluation (RDT&E) budget activities: Applied Research (6.2), Advanced Technology Development (6.3), Advanced Component Development, and Prototypes (6.4)[2]. In this construct, the JNLWP is able to

[2] DOD 7000.14-R Financial Management Regulation Volume 2B, Chapter 5, September 2012

facilitate the transition of promising S&T technologies by applying 6.4 resources for continued development, experimentation, demonstration and assessment beyond S&T. In an austere fiscal environment, this structure enables the JNLWP to complement Service RDT&E funds and nurture new technologies through the early stages of the acquisition process, thereby mitigating technical and programmatic risk.

Strategic Guidance

The JNLWP's S&T efforts are influenced by a series of national-level documents that outline the ends, ways, and means to be used for ensuring the nation's security. Guidance from such a strategic viewpoint does not explicitly champion the development of specific NLW S&T efforts, but rather offers an implicit direction as outlined below, and provides impetus for their development.

The Defense Strategic Guidance of January 2012 (*Sustaining U.S. Global Leadership: Priorities for 21st Century Defense*) provides the President's direction to the DOD at a time of transition relative to the wars in Iraq and Afghanistan and associated defense funding reductions. It reemphasizes the nation's enduring national security interests, provides the Commander in Chief's intent for defense and spending priorities for the following decade, and outlines a blueprint for Joint Force 2020. It portrays a Joint Force that is smaller and leaner, while still agile, flexible, and ready, in large part, as enabled by technological advancements. Key aspects of the guidance that impact NLW developmental efforts include rebalancing toward the Asia-Pacific region, deepening partnerships to ensure regional security, operating in anti-access/ area denial (A2/AD) environments, and ultimately prevailing in all domains. The guidance notes: "The United States will continue to lead global efforts with capable allies and partners to assure access to and use of the global commons, both by strengthening international norms of responsible behavior and by maintaining relevant and interoperable military capabilities."

The 2014 Quadrennial Defense Review (QDR) produced a strategy-driven and resource-informed document focused on preparing the DOD for the future and on prioritizing its efforts in a period of fiscal austerity. Built on the Defense Strategic Guidance to continue protecting and advancing U.S. interests and sustaining American leadership, the QDR's assessment of the challenging international security environment identifies plausible strategic and operational futures over the near-, mid-, and long-term, with particular emphasis on emerging threats, challenges, and opportunities. It notes the role of the DOD in supporting U.S. interests "is rooted in our efforts to reduce the potential for conflict, by deterring aggression and coercive behavior in key regions, and by positively influencing global events through our proactive engagement." It further states, "We will be principled and selective when using military force and do so only when necessary and in accordance with all applicable law, as well as with U.S. interests and U.S. values."

The National Security Strategy (NSS) of February 2015 reconfirms national level priorities by outlining the ways and means to safeguard our national interests through strong and sustainable leadership. It lays out the principles and priorities to guide the use of American

power and influence across the globe, and continues to emphasize the need to strengthen further U.S. and international capacity to prevent conflict among and within states, in part through providing leadership in S&T and innovation. It emphasizes that, "Scientific discovery and technological innovation empower American leadership with a competitive edge that secures our military advantage, propels our economy, and improves the human condition."

As a follow-on to the NSS, the June 2015 National Military Strategy (NMS) outlines the Chairman of the Joint Chiefs of Staff's rendering of the U.S. military's contributions to national security. It describes how the employment of our military forces will protect and advance our national interests through adapting to new threats, maintaining comparative advantage over traditional ones, supporting the other instruments of national power, enabling our network of allies and partners, and continuing to emphasize agility, innovation, and integration. The NMS provides an integrated approach composed of three National Military Objectives: to deter, deny, and defeat state adversaries; to disrupt, degrade, and defeat violent extremist organizations; and to strengthen our global network of allies and partners. It notes that the U.S. military pursues these objectives by conducting globally integrated operations, implementing institutional reforms at home, and sustaining the capabilities, capacity, and readiness required to prevail in conflicts that may differ significantly in scope, scale, and duration. It further states "we are aligning our programmatic efforts to take advantage of insights gleaned from the Defense Innovation Initiative, which is aimed at identifying potential strategic and operational advantages through wargaming, concept development, and a wide array of technology investments."

Strategic Drivers

The National and Military Strategic Guidance described above, along with other Joint and Service strategy documents, are relatively consistent in their renderings of the future security environment. They outline a complex, interconnected world that is increasingly locked together by trade and technology, while non-state actors and natural disasters continue to disturb what stability exists. Nearly all documents predict the U.S. will continue to be engaged in addressing terrorist groups and trans-national crime, but will do so by increasing the number of expeditionary and 'light' operations as opposed to sustained military campaigns. Their forecasts for the 2025 timeframe also include less well-understood trends that could affect upcoming developments of NLWs and how they are employed. These strategic drivers include:

- Megacities
- Engagement and Special Operations
- Emphasis on Non-Kinetic Fires
- Dispersed/Non-Linear Battlefields
- Unmanned Systems

Megacities

> "Globally, more people live in urban areas than in rural areas. In 1950, 30 per cent of the world's population resided in urban areas and by 2050, 66 per cent of it is projected to. Growth of megacities; currently 34 megacities with 24 along the littorals. By 2030, expected to be 39 and 28 respectfully" —*Department of the Navy: The Future of Naval Innovation*

Today, there are currently 34 megacities (cities with populations of ten million or more) in the world. A number that is expected to grow to nearly 40 during the next ten years[3], with many of them emerging in the Asia-Pacific region. In addition to being the 'epicenters of human activity', they are also expected to challenge future operational planners as they have been characterized by[4]:

- Poverty and social unrest
- Massive infrastructure limitations
- Environmental and pollution concerns
- Increased disease transmission due to close quarters and minimal sanitization and public health infrastructure
- Ungoverned neighborhoods and spaces
- Challenging demographics with young, unemployed citizens

Taken together, these megacity characteristics highlight the prospect of instability over stability— as they also hold a high propensity for unrest, disruption, and disorder on a large scale and will likely be the focus of urban operations as the Joint Force responds to future hotspots.

Figure 3: Current Largest Megacity in the World: Tokyo

The U.S. military is capable of operations in urban environments, but the mere scale of these megacities will present challenges in addressing security, intelligence gathering, strategic partnerships, and regional stability. This will require new capabilities and concepts, as well as changes to policy and doctrine. The Army Chief of Staff's Future Study Plan: *The Megacity: Operational Challenges for Force 2025 and Beyond* states it most succinctly: "To be effective in this

[3] United Nations, *World Urbanization Prospects: The 2014 Revision,* 13

[4] David Shunk, "Mega Cities, Ungoverned Areas, and the Challenge of Army Urban Combat Operations in 2030-2040," *Small Wars Journal*, 23 Jan 2014, http://smallwarsjournal.com/jrnl/art/mega-cities-ungoverned-areas-and-the-challenge-of-army-urban-combat-operations-in-2030-2040

sort of environment, security forces will need to blend police, infantry and military Special Forces. They must have the capability for highly granular intelligence collection and knowledge management and for rapid networking, partnership building and innovation." The effective employment of NLWs will be critical in the measured responses to situations our forces encounter in these challenging operating environments.

Engagement and Special Operations: Shaping the Future Security Environment

> *"*The diversity of threats to U.S. security and vital interests will increase the need for Army forces to prevent conflict and shape security environments ... While the ability to shape security environments through the threat of punitive action will remain important, Army forces conduct positive actions essential to reassuring allies, influencing neutrals, and dissuading adversaries." *—U.S. Army Operating Concept 2020-2040*

As the U.S. military looks towards future operations, it sees an increase in responsive actions to crises and disasters in dispersed regions across the globe. To enable these operations and help build Theatre Security Cooperation capabilities in the Combatant Commands (CCMDs), the DOD and Military Services have reinforced early engagement and capacity-building partnerships. These operations help countries become more able to deal with disasters/threats on their own, familiarize the U.S. government with operations in the country, and build trust among the governments and the military.

The importance of early engagement and building partner capacity to the Joint Force is reflected in the activities and organizations of the Military Services as they shift to an expeditionary mindset for future operations. The Army and Marine Corps are both organizing portions of their forces to be 'regionally aligned' and specialized in terms of a geographic area and region. Additionally, the Navy along with the Coast Guard have developed the Partnership Station concept within U.S. Africa Command and U.S. Special Operations Command to strengthen regional partners. The Air Force also performs partner-building operations to strengthen bonds between the U.S. and host countries.

Another important aspect of these operations is when conflict starts to build within an area, the U.S. can more easily deploy forces to shape the area of interest and prevent conflict from escalating past Phase 1.[5] These actions, typically performed by Special Forces, act as a damping mechanism to prevent conflicts from exceeding the response capabilities of local authorities and thereby ensuring a humanitarian or regional crisis does not spread across countries or regions.

NLWs have an important part to play in Phase 0/1 shaping, as they do in Phase 4/5 stabilization operations, and in low-impact Special Force operations. Not only will NLWs limit casualties and collateral damage from early phases of conflicts, but they could also prevent an undue

[5] Phases: In joint operation planning, a definitive stage of an operation or campaign during which a large portion of the forces and capabilities are involved in similar or mutually supporting activities for a common purpose. (JP 5-0). Phases: 0-Shape, 1-Deter, 2-Seize Initiative, 3-Dominate, 4-Stabilize, 5-Enable Civil Authorities.

escalation by limiting these effects. In addition, there are different restrictions and legal concerns sharing NLW technologies, tactics, and procedures with partner nations than with lethal destructive technologies. This increased level of sharing will help to build trust and capability among countries responding to emerging threats and destabilization.

Emphasis on Non-Kinetic Fires (e.g., Cyberspace Operations (Cyber), Directed Energy (DE), and Electronic Warfare (EW).)

> *"*Future battles will often be fought in population centers, driving policy makers to favor non-kinetic capabilities and alternate approaches to conflict resolution. A more connected and individually empowered citizenry will be less tolerant of destruction and casualties*" — 2015 Marine Corps Security Environment Forecast Futures 2030-2045*

U.S. efforts to minimize civilian casualties and collateral damage have steered the Services to consider the value of Cyberspace Operations (Cyber), Directed Energy (DE), and Electronic Warfare (EW) capabilities. These strategic and operational 'non-kinetic' fires have proliferated as Joint Forces have evolved the ability to operate in an increasingly complex environment. These are characterized by the pervasiveness of information technology, the increasing importance of signature management, challenges to electromagnetic spectrum access, and the globalization of Cyberspace capabilities.

Working together, non-kinetic fires and non-lethal effects can provide the warfighter a comprehensive toolkit that minimizes civilian casualties and produces low to no collateral damage. This coordination, in addition, enables a broader fires capability set that can be implemented from the strategic down to the tactical level, as well as across the range of threat capabilities from large computer networks down to the individual threat actor.

In particular, the advantages of DE with its expansive collaboration opportunities have spurred the JNLWP S&T Program to focus more attention to and increase investment in DE NLW efforts as a potential solution to multiple capability gaps.

Dispersed/Non-Linear Battlefields

> "The typical linear battlefield will be replaced by a combat situation with a 360-degree threat, the potential for new high tech weapons, the use of chemicals and biologicals, and the use of non-traditional forces and terrorism." — *Edward Martin, Strategies to Protect the Health of Deployed U.S. Forces. Characteristics of the Future Battlefield and Deployment*

The evolution of military operations from localized linear fronts to a dispersed/non-linear battlefield is not a new trend, and one that shows no apparent sign of halting or slowing. From the outset of future conflicts, both the Joint Force and any threat actors likely will be interspersed among the civilian population. Enemy forces understand this will disproportionally limit the freedom of action of the military and shadow the activities of non-state actors. In addition, the military, in its expeditionary operations, will be forward deployed further from

higher echelon support than in the past. This will result in units needing to be more self-sustaining and will lead to increasingly impactful decision making by junior personnel.

NLWs will be vital to address this ongoing trend. Among civilian populations, the need to avoid casualties and collateral damage takes on more importance to maintain an effective campaign. Additionally, NLWs will need to fit the form and function so that they easily complement the capabilities of the individual soldier. At the tactical edge, far from echelon support, the NLW's space, weight, and power requirements will take on even more importance.

Unmanned Systems

> *"*The propagation of this technology from both the commercial and military sectors will increase the risk of sophisticated UASs becoming available to any individual or group, regardless of their intent or financial resources. Current and future adversaries, including non-state actors, are likely to acquire and integrate UASs into their operations against U.S. forces." — *William Selby, Small Wars Journal. Operating in an Era of Persistent Unmanned Aerial Surveillance*

Unmanned systems (UxS), used almost exclusively by the U.S. military for decades, are evolving into a significant threat to U.S. forces as they become commercialized and ubiquitous across the globe. Commercial models are cheap, easily acquirable, require relatively little training to operate, and could be used for any number of purposes, including surveillance, targeting, and payload delivery. The threat presented by unmanned systems must be addressed in all phases of operations and domains[6], including offensive and defensive planning at the tactical through strategic levels.

Like all threats, lethal destructive force is not always required or beneficial to counter these systems. For instance, an unmanned aircraft system (UAS) that harasses U.S. forces from airspace over a protest limits a commander's alternatives as the debris could fall and injure civilians in the crowd. Likewise, a damaged unmanned surface vessel may become a hazard to navigation if its cargo is dangerous and remains buoyant. NLWs to address these threats and minimize collateral damage will be beneficial to the Joint Force as they are developed. Additionally, non-lethal stakeholders, who are actively engaged in unmanned technology forums, continue to ensure that emerging capability requirements are highlighted and addressed.

As with most military technologies, the growing UxS trend can have a positive impact on the development and utilization of NLWs. Unmanned systems can deliver non-lethal effects at distance, greatly increasing the effective range of non-lethal effects between 'shouting and shooting' and providing more time for escalation-of-force measures. This employment will only increase as the military expands the use of autonomous systems that can employ NLWs in accordance with DOD policy for autonomy in weapon systems (DODD 3000.09).

[6] Domains include air, land, sea, and undersea

3.0 UNIQUE ASPECTS IN DEVELOPING NON-LETHAL WEAPONS

To address the future operating scenarios envisioned in DOD and Service strategic guidance and better fill the capability gaps between 'shouting and shooting', the Military Services and other government agencies will require new materiel solutions as part of their comprehensive escalation-of-force capability set. NLWs, as part of the solution, will need to leverage innovative scientific advances and the DOD will need to invest in technology development efforts to sustain the technological advantage of the future warfighter. The development of NLWs is similar to the development of traditional weapon systems in the defense acquisition system, but there are unique elements of non-lethal technology that add both complexity and opportunity to the development process.

What Defines Non-Lethal Weapons?

The definition of what constitutes a 'non-lethal weapon' is specified in DOD Directive 3000.03E[7]. At its core, and for the purposes of this document, NLWs are defined by three tenets:

- Deliver immediate target response
- Provide predictable and intended reversible effects
- Minimize undesired collateral damage

NLW capabilities are further categorized into counter-personnel (CP) or counter-materiel (CM) core capability areas. Capability area tasks, seen below in Table 1, resulting from the 2008 Joint Non-Lethal Effects (JNLE) Capabilities Based Assessment (CBA) and the associated CP and CM Initial Capabilities Documents (ICD) dated April 2009, provide a broad foundation for the development of Joint and Service-unique NLW requirements and S&T objectives. Non-lethal capability development; however, is not limited to the target set or effects described in these documents.

Counter-Personnel Tasks	Counter-Materiel Tasks
• Deny access into/out of an area to individuals (open/confined) (single/few/many) • Disable individuals (open/confined) (single/few/many) • Move individuals through an area (open/confined) (single/few/many) • Suppress individuals (open/confined) (single/few/many)	• Stop small vehicles • Stop medium vehicles • Stop large vehicles • Disable vehicle/many vehicles • Stop small vessels • Stop large vessels • Disable vessel/many vessels • Stop fixed-wing aircraft on the ground • Divert aircraft in the air • Deny access to facility (i.e., block points of entry)

Table 1: NLW Core Capability Areas

[7] NLW Definition: Weapons, devices, and munitions that are explicitly designed and primarily employed to incapacitate targeted personnel or materiel immediately, while minimizing fatalities, permanent injury to personnel, and undesired damage to property in the target area or environment. NLW are intended to have reversible effects on personnel and materiel. (DODD 3000.03E)

Though the definition of what constitutes a NLW is clearly defined, NLWs are sometimes grouped with other capabilities that also produce other-than-lethal effects, including Cyberspace Operations and Electronic Warfare. While these capabilities do not all necessarily adhere to the three tenets of NLWs, they may offer additional opportunities for synergistic non-lethal effects that improve mission outcomes by together exploiting target vulnerabilities.

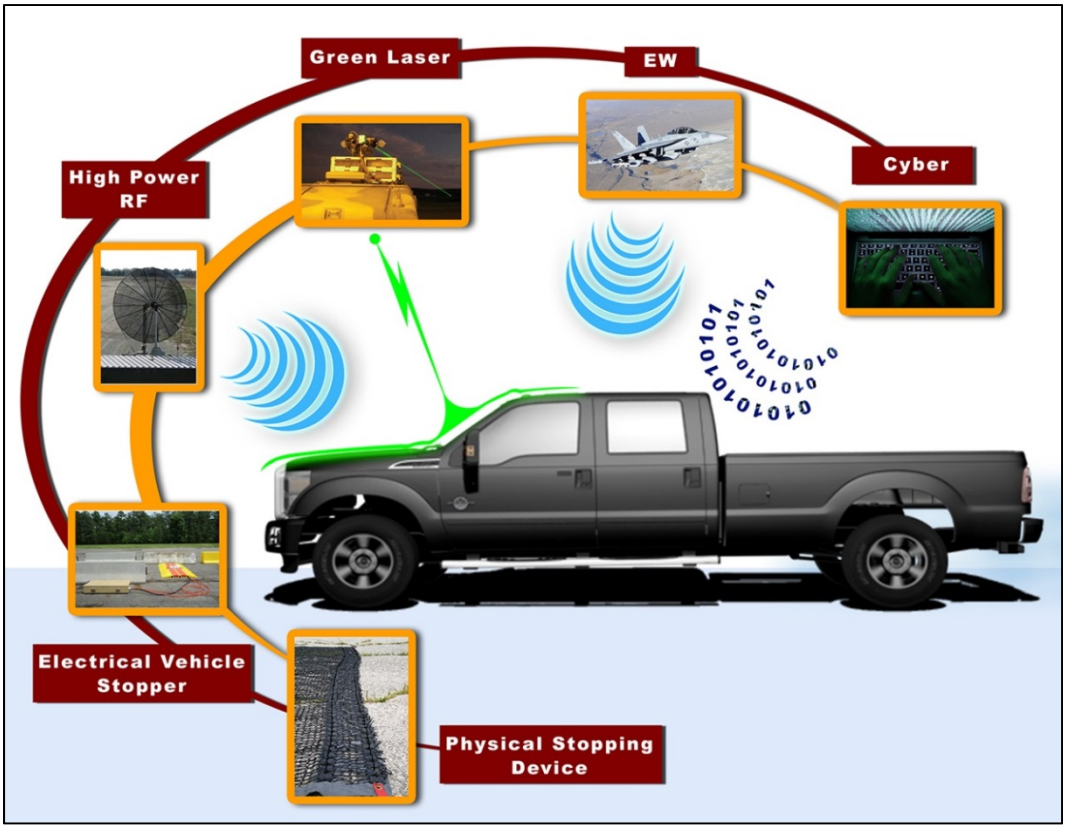

Figure 4: Exemplar NLW and other-than-lethal technologies on Vehicle Stopping

Vehicle Stopping Method	Technology/Warfare Area
Physical Barrier	NLW – Counter-Materiel
Electrical Disruption by High Voltage Current	NLW – Counter-Materiel
High Power Radio Frequency Disruption	NLW – Counter-Materiel
Dazzling Green Laser	NLW – Counter-Personnel
Navigation System Jamming	Electronic Warfare[8]
Vehicle Computer Control Interruption	Cyberspace Operations[9]

Table 2: Characterization of NLW and other-than-lethal technologies

[8] Military action involving the use of electromagnetic and directed energy to control the electromagnetic spectrum or to attack the enemy (JP 1-02)

[9] Cyberspace is a global domain within the information environment consisting of the interdependent network of information technology infrastructures and resident data, including the Internet, telecommunications networks, computer systems, and embedded processors and controllers (JP 1-02)

Figure 4 on the previous page conceptually demonstrates how various technologies could work independently or together to non-lethally stop or disable a vehicle. There is no "silver bullet," and the best technological approach or approaches for a given operational scenario will depend on many factors. For example, if employed at the tactical level, NLWs can be used by small dispersed units, while EW and Cyber assets are typically considered operational or strategic level assets that require higher-echelon support. Moreover, the rules of engagement (ROE) for NLWs vs. EW and Cyber assets could be markedly different based on the commander's discretion.

It is for this reason that the JNLWP works with other non-kinetic technology developers and communities to provide a comprehensive capability toolbox to the warfighter, for whom the approach to achieving the desired effect, within the ROE, is immaterial. S&T investment provides an opportunity for the JNLWP to seek out creative and synergistic solutions that may stretch the bounds of what is traditionally considered a NLW.

Figure 5: JNLWP High – Power Radio Frequency Vessel Stopping Prototype

Human Effects Characterization

Predictability, although highlighted in the second NLW tenet, is not a discriminator unique to NLW. For all DOD weapons systems, predictability of effects is critical to success. Commanders must understand what to expect when a capability is employed to decide how best to use (or not to use) it to achieve the mission at hand, and warfighters must have confidence that a given capability, once employed, will reliably provide the effects intended.

The desired effects of a lethal weapon system, for example, may be described in terms of lethality on target at a certain range or over a particular area. Similarly, a non-lethal weapon system's desired effects may be described in terms of a non-lethal outcome, such as denying an area or suppressing individuals, at a certain range, for a specified amount of time, or over a particular area. Those effects are further described in terms of reversibility, a unique aspect in characterizing NLW effects.

DOD Instruction 3200.19 establishes policy, assigns responsibilities, and provides procedures for human effects characterization in support of the development of NLWs. This

characterization is vital to describing a NLW's potential to be predictable and reversible[10]. The JNLWP S&T Program invests in physiological effects as well as behavioral response research to enable effective DOD human effects characterization and inform DOD NLW system requirements, design, test and evaluation.

Below is an illustrative diagram reflecting the complexity that arises when developing NLWs. On the left is a typical lethal weapon effectiveness analysis. As one expects, an increase in 'dose' typically leads to a more lethal and effective weapon. That dose amount is then balanced against other factors when designing a weapon to meet the threshold or objective performance criteria for the required capability.

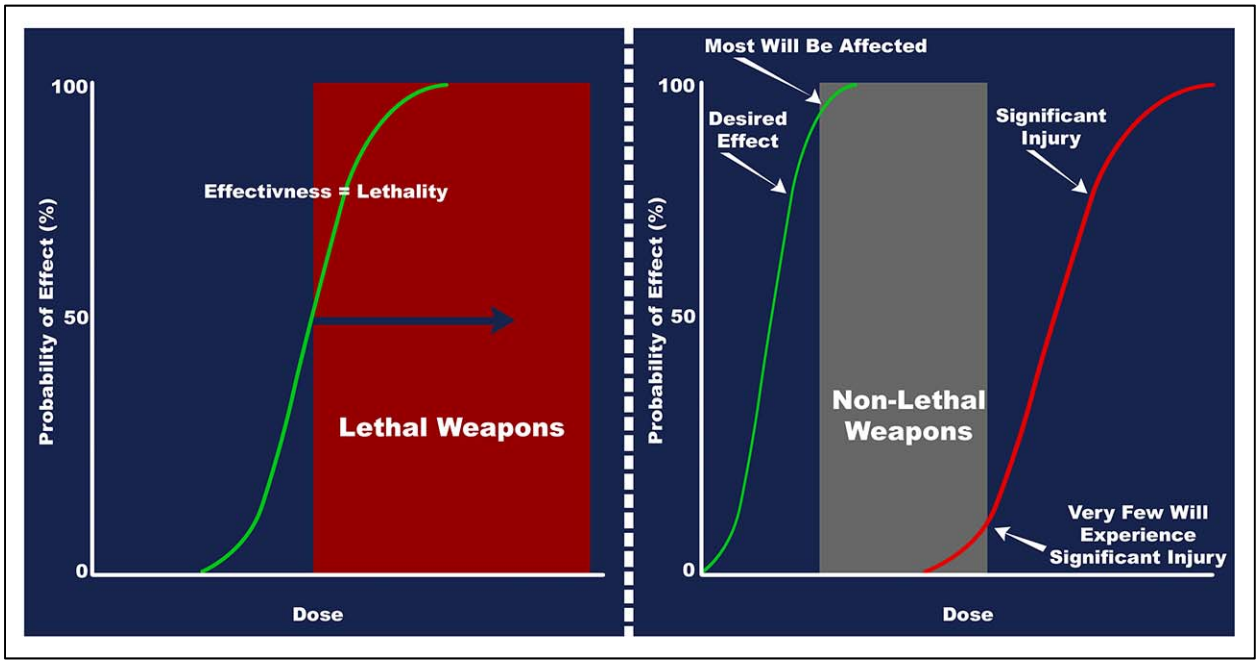

Figure 6: Lethal and Non-Lethal Weapon Trade Space Comparison

As illustrated on the right, NLWs developers must identify the necessary 'dose' to achieve desired effects (predictability), while remaining within the bounds of acceptable injury risk (reversibility). This area in-between is referred to as the 'operating envelope,' and it varies widely across the spectrum of NL stimuli and systems. Though the diagram is intentionally simplistic to convey the concept, examination of the trade space between the bounding 'dose' response curves can be extremely complex. It is for these reasons that S&T research to define these trade spaces is critical to the success of NLWs development.

[10] DODI 3200.19 defines Risk of Significant Injury or RSI as the parameter used to describe reversibility of NLW as it relates to human effects

4.0 JNLWP S&T OBJECTIVES

To realize the JNLWP S&T intent to 'foster the ideation, maturation, and demonstration' of new NLW technologies for the Joint Force in the 2025 timeframe, the program has established a series of Science and Technology Objectives or STOs. These objectives are not specific end-states or programmatic metrics of the JNLWP S&T portfolio[11], but instead guide the development of future warfighter capabilities that are based on Joint requirements and shaped by the published strategic guidance outlined previously.

The STOs in this document serve as guideposts for S&T investment within the JNLWP and help to communicate the direction of the JNLWP S&T Program to its stakeholders. While the strategic drivers in section two influence and shape the general direction of JNLWP S&T investment, it is capability requirements and technology opportunities that drive specific NLW S&T objectives. Those drivers are reflected in the dual structure of the JNLWP STOs:

- **STO – Capability (STO-Cs):** S&T objectives that are tied to requirements within the Initial Capability Documents (ICDs) for Counter-Personnel and Counter-Materiel Joint Non-Lethal Effects (JNLE) and/or emerging requirement demand signals from the Military Services and CCMDs. The STO-Cs are not inclusive of all non-lethal requirements, but instead are a selected list developed to identify the most pressing NLW capabilities required in the expected future operating environment.

- **STO – Enabler (STO-Es):** S&T objectives that will help advance the state-of-the-art or increase the knowledge based for the most promising NLW technologies. These objectives are organized by a particular technology or family of technologies that have proven non-lethal efficacy to the warfighter, but require further research and/or development to optimize their utility.

Annex A provides STO summary tables for quick reference.

STO Attributes

Both categories of STOs are designed to be strategic 'stepping stones' for achieving new non-lethal capabilities and knowledge products. Complex technological innovations and research questions often call for an iterative approach, learning from results and re-shaping the path forward as needed to meet the mission. Reinforcing this design philosophy, the objectives are divided into near-, mid-, and far-term goals. These descriptors provide a temporal context, but since S&T efforts are inherently risky as they do not tie the STOs to absolute timeframes, In general, and for the purposes of this plan, near-term refers to one to three years (FY16-18), mid-term refers to three to six years (FY19 – 21), and far-term six years and beyond (FY 22+).

In addition to addressing a candidate technology's ability to meet the S&T objective within a relative timeframe, the idea will also be assessed by way of additional features, which will

[11] The JNLWP S&T programmatic method is discussed in section five

facilitate the JNLWP in the efficient use of its resources in support of the JNLWP S&T Program's intent. The attributes below have been shown to be successful transition discriminators, which have eased the transfer of technology to provide effective, affordable, and timely solutions for the Joint Force in an era of rapid technological change. These include:

- **Applicability:** S&T efforts that can be broadly applied across multiple efforts or capability objectives as opposed to a single program or effect. These include applicability across the range of military operations, environmental conditions, and warfare domains, in addition to fulfilling the cross-Service nature of the JNLWP.
- **Scalability**: Technologies that can be applied across the escalation-of-force continuum, against targets of various sizes, requiring different applications of power. Optimally, this should be a seamless integration of technological capabilities that spans the non-lethal/lethal continuum, which replaces multiple disparate weapon systems.
- **Modularity**: Technologies developed around modular components that easily can be integrated into current and future warfighting systems in a modular or 'plug and play' fashion through the use of 'standardized' inputs and outputs.
- **Space, Weight, Power, and Cooling (SWAP-C) Requirements**: Technologies that can reduce SWAP-C requirements for warfighters and minimize the logistics burden of deployment and employment. The reduction should enable the NLW capability to complement other weapon systems and reduce the need for dedicated NLW platforms.

The characteristics described above are some of the features that ease the transition of S&T projects into knowledge products or programs of record for the Joint Force. They help reduce the barriers to integration within the Military Services and lower integration and lifecycle costs[12]. Additionally, these discriminators lessen the need to adjust current doctrine, organization, training, materiel, leadership & education, personnel, facility, and policy (DOTMLPF-P) demands when incorporating a new technology.

The end state of a particular S&T project and what constitutes 'success' may vary widely depending on its intended outcome, relative priority, and the programmatic, fiscal and technical environment. In some instances, the JNLWP may choose to develop further high Technology Readiness Level (TRL) prototypes for use in rigorous and realistic military utility assessments. In other cases, the end state may be a demonstration of a lower-TRL laboratory system in a controlled environment. These STOs are broad objectives, which communicate the JNLWP path forward with defined metrics without limiting potential technology solutions, platforms or mission applicability. In particular, specific project end states associated with STO-Cs are developed in coordination with stakeholders and with primary considerations for their concepts of employment.

The STOs reflect the JNLWP's S&T priorities at this time, but do not necessarily represent the full extent of the current or future S&T program portfolio. Although any S&T investment is

[12] U.S. Department of Defense, *Manager's Guide to Technology Transition in an Evolutionary Acquisition Environment*. (Washington, DC: Office of the Undersecretary of Defense for Acquisition, Technology and Logistics, January 2003)

inherently risky, research and technology development efforts can vary widely with respect to their potential costs to benefit. The JNLWP must consider its 'return on investment' when building its project portfolio, in addition to acknowledging that future emerging non-lethal requirements and emerging innovative technologies may dictate an eventual change in the path forward. With this understanding, the JNLWP has established a recurring STO review process to ensure future efforts and investments remain closely aligned to warfighter needs, and which foster innovative solutions and programs.

4.1 STO – Capability (STO-C)

Counter-Materiel

Today's fielded NLWs focused on counter-materiel capabilities are balanced heavily towards base and port security requirements with installed or pre-emplaced systems that emphasize force protection. However, the ability to move with the force and engage targets at a distance will increase in significance as the DOD shifts from established operational areas, bases, and ports, to more austere and expeditionary operations located in megacities and across the Asia-Pacific region. The ability to engage targets rapidly and effectively is required as forces are employed concurrently across multiple operating areas in dispersed non-linear battlefields. The STOs below are designed to focus technology breakthroughs on enabling expeditionary and dispersed operations, where units are intermittently on-the-move and operating as a detachment that is not co-located with higher-level support.

Counter-Materiel - Vehicles

Range and mobility are the most limiting challenges for current and emerging non-lethal counter-vehicle capabilities. Independently, range and mobility can be achieved with the currently available technology, but concurrently achieving both requires further S&T investment. This STO is informed by known limitations of existing mechanical solutions (i.e., barriers and entanglement devices), as well as the state-of-the-art for electrical injection devices and emerging directed energy technologies. This STO will provide for demonstration of a near-term capability for limited range force application and force protection missions, while seeking to demonstrate extended range and additional mission versatility in the future. Modularity, transportability and broadly applicable effects are important attributes in all cases.

Timeframe	STO–C: Counter-Materiel - Vehicles
Near	Tactically transportable multi-mission modular system capable of stopping individual vehicles of any size/weight/speed. Demonstrate stationary capability to affect vehicle targets at long range (175m) [13], as well as mobile capability to affect targets at short ranges (50 m) while system is on-the-move.
Mid	Mobile multi-mission modular system capable of stopping individual or few vehicles of any size/weight/speed at long ranges (175m) to support convoy operations. Demonstrate capability to perform operations while on-the-move and affect targets at tactically relevant duty cycles.
Far	Mobile multi-mission modular system capable of stopping and disabling individual or few vehicles of any size/weight/speed to support short- and very long-range (greater than 2,200m) force application operations. Demonstrate capability to perform operations while on-the-move and affect targets at tactically relevant duty cycles.

Counter-Materiel - Small/Medium Vessels

As in counter-vehicle capabilities, range is also a pressing challenge for developmental counter-vessel capabilities— perhaps even more so considering the uniqueness of the maritime domain and environmental factors that can interfere with effectiveness (e.g., salt spray and variable sea states). While counter-vessel capabilities have utility in fixed pier-based operations, with the future focus on expeditionary operations, the JNLWP S&T Program, in addition to range, is placing emphasis on vessel platform compatibility and integration. This STO is informed by known current limitations of existing mechanical solutions (i.e., barriers and entanglement devices), as well as the state-of-the-art for advanced material payloads and emerging directed energy technologies. This STO will provide for demonstration of a near-term capability for limited range force application and force protection missions, while future S&T investment will focus on demands for broader effects at extended ranges, against larger target vessels, and in higher sea states. These future NLW efforts will include exploring the potential for aerial or unmanned systems to aid in the delivery of non-lethal effects to target vessels.

[13] Objective system ranges (175m & 2200m) are derived from estimated potential lethal air blast and falling glass hazard ranges for vehicle-borne explosive devices

Timeframe	STO–C: Counter-Materiel – Small/Medium Vessels
Near	Vessel platform-compatible system capable of stopping individual small vessels on the surface at a range of at least 100m from employment vessel in restricted waters or littorals.
Mid	Vessel platform-compatible system capable of stopping multiple small or medium vessels on the surface at a range of at least 500m from employment vessel in restricted waters or littorals.
Far	Vessel or aircraft platform-compatible system, manned or unmanned, capable of concurrently stopping or disabling multiple small or medium vessels greater than 1km from a host vessel or aircraft in the open ocean up to sea state 3.[14]

Counter-Materiel - Unmanned Systems (UxS)[15]

The growth of unmanned systems has emerged as a new threat to forces overseas and in the United States. Their pervasive proliferation, across the range of military operations, has recently sparked a significant demand signal for non-lethal means to counter their employment.

Timeframe	STO–C: Counter-Materiel – Unmanned Systems (UxS)
Near	Survey the requirements and technology landscape to determine the extent of the JNLWP S&T Program's role in developing solutions for this emerging focus area. Further develop the strategic objectives, as appropriate, in coordination with relevant stakeholders.

Counter-Personnel

The anticipated future operational environment will drive the development of smaller, more capable non-lethal counter-personnel capabilities. Forces operating in megacities and as dispersed small-units will need the capability to quickly control crowds with a large number of civilians and potential threat actors relative to their own formations. Such engagements will demand a wide spectrum of non-lethal counter-personnel capabilities (move, deny, suppress, and disable)[16] at increasingly longer ranges, larger areas of coverage, and for longer durations, to include operations in uniquely limiting environments (i.e., the maritime and air domains). In all cases, scalable effects will be preferred to facilitate escalation/de-escalation-of-force and provide maximum flexibility and adaptability to the mission.

[14] Wave height 0.5 – 1.25 meters

[15] UxS include aerial, ground, surface and subsurface systems

[16] **Move -** To go or pass to another place or in a certain direction with a continuous motion; **Suppress** – To degrade the ability of an individual to take specific action; **Deny** – An action to hinder or prevent the use of space, personnel, or facilities; **Disable** – To render ineffective or unable to perform

Counter-Personnel – Move and Deny

Currently fielded and near-term developmental NLW capabilities can reliably achieve 'move' and 'deny' effects, but are typically range limited and are often not as effective against non-compliant personnel. S&T investments will therefore focus on expanding the operationally effective range envelope and developing solutions that compel even the most motivated individuals to move or remain out of an area[17]. Priority will be placed on demonstrating NLW capabilities with the potential to meet or exceed relevant documented requirements.

Similar to counter-materiel capabilities, future counter-personnel capabilities will need to be more agile and move with the force. This will call for investment in advanced targeting/tracking and reductions in SWAP-C to increase significantly the mobility and the breadth of mission applicability.

Timeframe	STO–C: Counter-Personnel – Move and Deny
Near	Move, and/or deny access to multiple, compliant and non-compliant[18] individuals at 300m from a tactically transportable NLW system.
Mid	Move, and/or deny access to multiple, compliant and non-compliant individuals at 300m from a tactical vehicle platform while stationary or on-the-move.
Far	Move, and/or deny access to multiple, compliant and non-compliant individuals up to 300m from a crew-served or individual system while on-the-move.

Counter-Personnel - Suppress

Current suppression technologies, primarily based on highly volatile pyrotechnic and explosive energetics, are, for the most part, not compatible with operations onboard airplanes or onboard maritime platforms due to concerns over flammability and structural integrity. This STO supports technology developments into new methods or techniques for the suppression of multiple compliant and non-compliant individuals in those constrained environments.

Timeframe	STO–C: Counter-Personnel – Suppress
Mid	Suppress multiple compliant and non-compliant targets in a confined space onboard aviation/maritime platforms.

[17] Areas to include confined spaces (An area of varying dimensions and size that has limited or restricted avenues to enter, egress or evade engagement) and open space (Any area large enough to allow a target, relative to its size, unlimited avenues to enter, egress, or evade engagement)

[18] A non-compliant target is one who exhibits passive resistance, active resistance, aggression, and/or assaultive behavior in response to a non-lethal effect or is otherwise unaffected/unaware of a non-lethal effect

Counter-Personnel – Disable

The current disable NLW portfolio can engage individuals at close range and for only a short duration of time/effect. Mid-term objectives, and eventually far-term objectives as they come into focus, will aim to increase the range, duration of effect, volume of fire, and number of individuals a NLW system will be able to engage.

Timeframe	STO–C: Counter-Personnel – Disable
Mid	Disable an individual between 2–100m for 1 minute.
Far	Disable multiple individuals in a confined space without precise target location information for 1 minute.

Counter-Facility and Equipment

The need to temporarily disrupt the normal operations of facilities and equipment with reversible counter-personnel or counter-materiel effects is expected to increase with more operations in megacities and with threat actors using protected facilities such as hospitals and schools to gain an asymmetric advantage. The need for non-lethal counter-equipment is still emerging (e.g., security/alarm systems and cell phones) and will require close coordination with the Military Services and CCMDs to determine how to best develop viable solutions for force application. These two NLW capability areas also provide an excellent opportunity to closely coordinate with other non-kinetic effects areas (i.e., Cyber and Electronic Warfare) to provide additional options for achieving desired effects on these targets for the warfighter.

Counter-Facility

Counter-facility capabilities are currently under-developed in the JNLWP S&T portfolio. NLW technologies capable of temporarily securing a facility or building can support the anticipated increase of future operations in megacities, along with the associated tight Rules of Engagement (ROE) in these heavily populated urban areas. These NLW technologies have the potential to protect patrol routes or secure a unit's flanks from enemy infiltration through a facility or building, while stationary or on-the-move.

Timeframe	STO–C: Counter-Facility
Mid	Conduct exploratory studies and investigate promising technologies for counter-facility applications and utility.
Far	Deny access to a facility or vessel for no less than 60 min.

Counter-Equipment

Counter-equipment capabilities are still emerging as a NLW focus area, but they are rapidly gaining traction due to the prevalence of electronics and communication equipment on the modern battlefield. This STO supports new technologies and methods to degrade target electronic equipment in a reversible manner, while minimizing collateral damage in a synergistic capability with other warfighter tools and techniques.

Timeframe	STO–C: Counter-Equipment
Near	Disrupt and/or degrade targeted electronics of accessible individuals/targets.
Mid	Disrupt and/or degrade targeted electronics of specific facilities.
Far	Disrupt and/or degrade targeted electronics of specific facilities, including hardened/military targets.

4.2 STO – Enabler (STO-E)

Directed Energy Technologies

Directed energy (DE) technologies seek to exploit the electromagnetic spectrum to non-kinetically target individuals, equipment, or facilities, with non-lethal effects. The benefits of non-lethal DE technology is apparent in the potential to augment current lethal and non-lethal capability sets. Today's directed energy weapons (DEW) are capable of delivering non-kinetic effects over long distances nearly instantaneously, reducing the ammunition logistics burden to the warfighter, also, they are generally less costly on a per-shot basis compared to the threats they are engaging. DEW scalability also enables the potential for graduated effects between 'shouting and shooting' within one system. Future non-lethal DEWs may also provide improved area coverage with their extensive 'depth of magazine' and agile beam- steering capability.

Recognizing the many potential applications for DE across multiple NLW capability gaps, the JNLWP S&T Program has increased its focus and funding on this promising enabling technology area. The JNLWP's intends to continue its investment in non-lethal DE technology to mitigate various persistent limitations of fielded NLWs to include, range, scalability, duration of effect, and diversity of susceptible targets.

The JNLWP DE Portfolio focuses on two major capability areas. The first capability area is the means to stop vehicles, vessels, and other systems with High Power Radio Frequency (HPRF) electro-magnetic energy. The second capability area involves compelling individuals (to move, deny, suppress, or disable) with millimeter waves (mmWave[19]) electro-magnetic energy

[19] mmWave ranges from 30 GHz to 300 GHz

commonly referred to as Active Denial Technology (ADT). In both of these areas, JNLWD prototypes have proven highly effective at their respective missions and operationally suitable for some situations; however, they are still generally considered too large, heavy, or cumbersome for a wider array of potential applications. Near-term objectives focus on reducing system SWAP-C to increase operational suitability and supportability, while mid- and far-term efforts aim towards novel methods and innovative technologies to generate advanced effects.

The JNLWP is a technical leader in DOD DE developments, especially as relates to HPRF and mmWaves. The JNLWP plans continued investment in this game-changing technology area for NLWs and will continue to contribute to DOD technical and policy working groups to help shape a DOD -wide DEW path forward. There are great opportunities to leverage mutually beneficial investments in DEWs by the wider DOD community, and to allocate more efficiently resources to overcome common technical and policy hurdles. The JNLWP will remain actively in the forefront of DE to better help Joint Warfighters gain and maintain a competitive advantage over potential adversaries with DEWs.

Timeframe	STO–E: High Power Radio Frequency (HPRF) Technology
Near	Increase system reliability of HPRF technologies by advancing the development of megawatt class waveguides and rotary joints, innovative dielectrics and insulators, and on the characterization of optimal frequency and peak power requirements for various target sets.
Mid	Develop solid-state and tunable HPRF sources, as well as validated and verified target models and effectiveness optimization techniques, to reduce SWAP-C of HPRF sources.
Far	Pursue electronically steerable HPRF and the development of a non-line-of-sight HPRF weapon or payload for increased expeditionary and mobile operability.

Timeframe	STO–E: mmWave Active Denial Technology (ADT)
Near	Advance SWAP-C attributes of ADT systems to gain efficiencies in prime (input) power generation, in 95 gigahertz mmWave source (output) power generation, in overall system cooling capacity, on novel antenna configuration. Pursue technologies to more accurately aim and engage target individuals with ADT.
Mid	Develop follow-on solid-state and vacuum tube tunable mmWave sources to further optimize the various current first-generation ADT technologies for more effective short-range (0-500m), and long-range (500-1,000m) ADT variants. Investigate mmWave trade space to compare system effectiveness and duty cycles with waveforms other than 95 gigahertz.
Far	Pursue emerging compact and efficient source technologies. Investigate man-portable ADT systems. Incorporate mmWave modules alongside other lethal and non-lethal weapons.

Human Effects Characterization Technologies

Human effects characterization is vital to all NLW development to determine the effectiveness of the technology in creating immediate predictable effects with minimal risk of significant injury. In the past, this characterization followed the S&T development of the weapon technology and required human effects understanding to 'catch-up' to meet system development efforts. This approach resulted in delays to operational fielding and constricted the design trade space of NLWs.

Since these initial NLW efforts, human effects characterization projects have been, and will continue to be, closely synchronized with technology development. Investments in determining the physiological effects of generalized NLW stimuli on human biological systems, as well as the development of holistic modeling solutions and testing surrogates are crucial to the success of the JNLWP and the fielding of operationally relevant NLW technologies.

Timeframe	STO–E: Human Effects Characterization
Near	Mature predictive models and surrogates to support current projects and programs (e.g., sound and light, blunt impact and human electro-muscular incapacitation,) Development of a thermal nociceptor model in support of mmWave trade space investigations.
Mid	Develop predictive behavioral models for non-lethal stimuli to include combined NLW effects.
Far	Develop models and surrogates for future NLW stimuli and technology investments to ensure synergistic system development with emerging NLW technologies.

Sound and Light (S&L) Technologies

The sound and light (S&L) technologies portfolio focuses non-lethal effects to target individuals within the visual and auditory spectrums that humans use to sense external stimuli. The use of low-power lasers and long-range audio devices to hail and warn target individuals at range will increase the time available to evaluate their intent. Consequently, S&L technologies may be used to exploit human visual and auditory perception at a distance with an escalation-of-force output appropriately scaled to hail, warn, move , deny, or suppress target individuals—resulting in a relatively small risk of significant injury.

Current S&L objectives also aim to develop new methods of delivering sound and light effects without the flammability and structural integrity hazards associated with the traditional highly volatile pyrotechnic flash-bang munitions, and in form factors that will significantly reduce their SWAP-C and yet maximize their mobility and versatility. Longer-term goals include projecting S&L effects across longer distances and through barriers to increase the reach of S&L to increase standoff and more effectively implement the warfighter's decision-making cycle.

Timeframe	STO–E: Sound and Light – Escalation-of-Force at a Distance
Near	Reduce SWAP-C of acoustic drivers with increased one-way range and intelligibility, improve stabilization and targeting capabilities, and incorporate optical-aid safety mitigation technologies.
Mid	Investigate electronic acoustic beam steering, and develop novel acoustic drivers for improved one-way range and intelligibility. Integrate S&L technologies with other non-lethal or lethal weapon platforms to achieve a broader escalation-of-force capability.
Far	Develop man-portable S&L systems for distributed, dismounted operations, and explore novel technologies to transmit intelligible sound through structural barriers.

Timeframe	STO–E: Sound and Light – Flash & Bang
Near	Investigate non-pyrotechnic derived flash-bang devices that meet or exceed the sound and light output of fielded pyrotechnical flash-bang devices.
Mid	Incorporate non-pyrotechnic flash-bang technology into other weapon form factors.
Far	Develop effects applied from a distance using DE technology. Seek novel technologies to reduce SWAP-C for a grenade sized non-pyrotechnic flash-bang device.

Human Electro-Muscular Incapacitation (HEMI) Technologies

Human electro-muscular incapacitation or HEMI technologies use electric pulses to suppress and disable targets. The current systems deliver charges through thin conductors that engage with the skin and induce involuntary muscle contraction. Advances in electrical waveforms and novel methods to engage multiple targets at increased distances and in confined spaces will increase the potential applications for the technology, while using less power and incorporating smaller form factors.

Timeframe	STO–E: Human Electro-Muscular Incapacitation (HEMI)
Near	Develop methods to project HEMI effects to longer ranges. Investigate methods to improve accuracy by controlling propulsion and flight stabilization. Improve sighting and electrode attachment, while reducing chances of significant injury.
Mid	Research novel electrical waveforms, to include sub-microsecond pulses, and their potential to improve counter-personnel capabilities (e.g., duration of effect).
Far	Incorporate multiple electro-muscular incapacitation engagement capabilities in a modular form factor. Develop HEMI projectiles or payloads that can disable or suppress multiple targets in an area.

Innovation Opportunities

The JNLWP is continually seeking out novel ways to address unanswered capability gaps and research questions. Universities, government laboratories, industry, and small businesses – both domestic and international – most often drive advancements in the state of the art. To best leverage that innovation, the JNLWP S&T Program routinely engages with government laboratories and uses broad agency announcements (BAA) to reach non-government innovators.

The STO-Es for Innovation are intentionally broad and intended to provide insight into potential future investment areas. These areas have potential value to support the Joint Force, but are currently limited by fiscal constraints, technological state-of-the-art, or operational considerations. While no investment is currently planned in these areas, they may be the subject of collaborative partnerships or future plans sought out in a BAA.

Focus Area	STO–E: Innovation
Counter-Materiel Capability and Technology	o Subsurface vessel stopping o Large vessel stopping o Combustion modifiers o Counter-aircraft
Counter-Personnel Capability and Technology	o Laser counter-personnel effects o Clear confined spaces without entry o Non-irritating malodorants o Counter-swimmer
NLW Human Effects Research	o Cultural response differences to NLW stimuli
General Research Areas	o Autonomous NLW delivery systems and payloads o Advanced materials

5.0 JNLWP S&T PROGRAM MISSION, SCOPE, AND PROCESS

To realize the stated S&T objectives by 2025, the JNLWP S&T Program's mission is to manage efficiently and effectively an S&T portfolio that delivers transition-ready technologies and risk-reduction products aligned with priority NLW needs and capability gaps. The Director, JNLWD through the S&T Manager directs the effort and establishes a diverse portfolio through the following S&T project end-states:

- Assess feasibility, effectiveness, and injury risk of innovative solutions
- Conduct technology and effects trade space analysis to inform system design
- Investigate and develop solutions to maximize operational suitability
- Demonstrate or integrate new or improved capabilities
- Develop/mature predictive models and test assets to enable/facilitate test and evaluation

Although S&T projects have an inherent level of risk and may not reach their predicted performance goals, all of them are considered S&T successes through one or more of the following outcomes:

- Transition to the Joint Force. A demonstrated capability becomes a materiel solution for a Joint or Service-unique requirement. The technology may be transitioned in support of a new Technology Maturation and Risk Reduction initiative, transitioned as new program of record, inserted into an existing of record, or rapidly fielded.

- Develop into an R&D Project or Engineering Prototype. A demonstrated capability - for which a specific requirement is not yet defined - is further developed for continued experimentation, demonstration and assessment with the intent of reducing risk and stimulating requirements for the nascent technology.

- Reduce Risk for Acquisition Initiatives. Models, research findings, and technology feasibility assessments inform combat and materiel development for Joint and Service-unique acquisition initiatives. S&T products are used to assist in identification of appropriate and testable system attributes, provide insight on the design trade space, and enable system test and evaluation, thereby reducing technical and programmatic risk.

- Transition to another Government Agency or Commercial Industry. Although the JNLWP prioritizes the development of capabilities for the Joint Force, transition of a demonstrated capability to another government agency or industry would also be considered a positive outcome.

- Contribute to the State-of-Knowledge and Inform Future Investment. An S&T knowledge product is shared with the public or appropriate Government, industry, academic, and international partners. Research hypotheses are sometimes proven wrong, and technology concepts are sometimes found to be flawed or limited to a particular

application. S&T is an inherently risky endeavor, but in order to maintain technical superiority, the DOD R&E Enterprise must take chances on cutting-edge science and technology. Both successes and failures can be expected, but regardless the knowledge gained, when properly documented and shared, knowledge products can help to advance the state-of-knowledge and inform future DOD investment.

JNLWP S&T Program Process

The JNLWP has instituted a two-year S&T programmatic planning and execution cycle that provides continuity for multi-year investments while maintaining flexibility to respond to emerging S&T needs from the operational forces and the Combatant Commanders. The process, shown below in Figure 8, maximizes communication opportunities with internal and external stakeholders and aligns programmatic decisions to inform and be informed by the DOD Planning, Programming, Budgeting, and Execution process and DOD R&E enterprise.

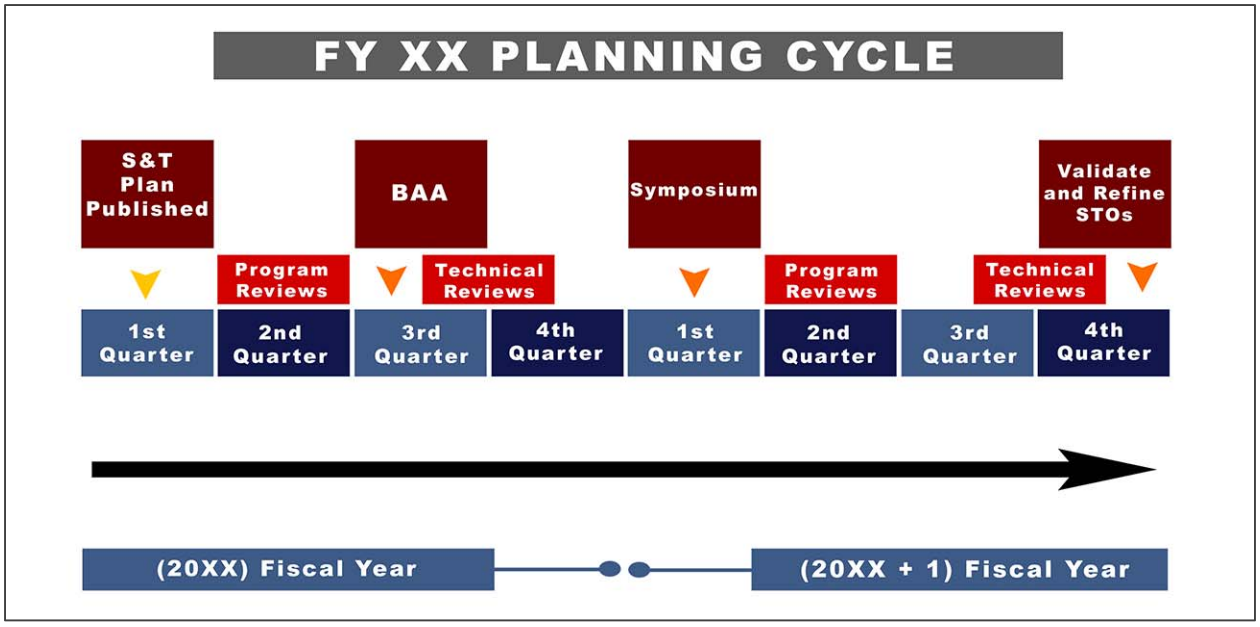

Figure 8: JNLWP S&T Two-Year Planning Cycle

The two-year process starts with the publication of the JSTSP and its associated STOs in the first quarter of every other fiscal year (FY). As described above in Section 4, these STOs are derived from validated and emerging capability requirements and are developed with input from authoritative publications that describe the future operating environment and provide national defense, security and military strategies. These strategic level documents provide guidance to the JNLWP on what objectives should be developed or refined for the future and inform external communications to stakeholders on the value of planned JNLWP S&T investments.

During the second quarter of each FY the JNLWD conducts programmatic reviews for ongoing and new-start S&T projects. Cost, schedule, and performance are the foci of these reviews, for which the Director of the Joint Non-Lethal Weapons Directorate is the primary audience. The

programmatic reviews are intended to inform in-year execution decisions as well as future-year project-specific investment decisions. The programmatic reviews also serve to inform the JIPT FYDP validation in the third quarter for the following FY.

In the fourth quarter of each fiscal year, the JNLWD will conduct Technical Reviews. These reviews, unlike the programmatic reviews, will focus on addressing the degree to which JNLWP S&T investments meet the STOs. For STO-Cs, Service representatives will assist in the assessment and make recommendations to refine the path forward. For STO-Es, scientific and technical subject matter experts will provide feedback on the developmental approaches and research methodologies. Results of the technical reviews will be documented and used to inform the next iteration of the JSTSP to be published in the first quarter of the following two-year cycle.

Other externally oriented planning cycle events include the JNLWP S&T BAA and a NLW S&T Symposium. Published biennially, the BAA is intended to broadly canvas the industrial base for innovative solutions to the toughest NLW challenges; it seeks new ideas and may result in expansion into "innovative technology" areas pending available resources[20]. Also conducted on a biennial basis (in "non-JSTSP/BAA" years), a NLW Symposium is another way to facilitate focused communication, collaboration and coordination between NLW community stakeholders. This can be a JNLWD led effort or JNLWD participation in a relevant symposium that brings together NLW stakeholders in an environment that fosters communication and engagement.

As another key component to the JNLWP S&T process, external third party reviews will be held on an ad hoc basis during the planning cycle for specific projects to validate and seek peer review of NLW research and technology development plans.

[20] The process is intended to be phased in over time. The first S&T BAA that will benefit from this progression is planned for solicitation in FY 2018 with awards in early FY 2019

6.0 NLW S&T COLLABORATION AND ACQUISITION APPROACH

Scientific discovery and technological development are rarely performed in a vacuum, but instead are discussed, investigated, challenged and confirmed among teams of scientists and engineers building on the works of others. The JNLWP seeks out the best science and engineering talent in government laboratories, academia, and industry — including small business and non-traditional sources — to develop creative solutions and execute the JNLWP S&T project portfolio. To effectively reach out to this talent and ensure that the JNLWP S&T budget is most efficiently executed, the JNLWD uses a diverse and multi-faceted collaboration and acquisition approach. This approach enables the JNLWP, and ultimately the DOD NLW Program, to capitalize on the strengths, resources, and unique capabilities of national and international partnerships. Given resource constraints, proactive collaboration and frequent communication with experts and innovators across disciplines and communities of interest offer the best opportunity for advancing non-lethal technology.

The collaboration and acquisition approaches described below are not intended to be all-inclusive of the methods used by the JNLWP S&T Program. Rather, they highlight those on which the JNLWP places emphasis to achieve its intent, 'Foster the ideation, maturation, and demonstration of innovative and compelling NLW technologies for the Joint Force through focused investment and collaboration internal and external to the DOD R&E Enterprise.'

DOD NLW Program

As reflected in Chapter 3, the DOD NLW program is far broader than the Joint Program. Each Service is responsible for maintaining its own Service-unique NLW competency. The JNLWP maintains insight into these Service-unique investments and routinely engages with stakeholders to achieve S&T outcomes to advance the state-of-the-art knowledge and ultimately provide the warfighter with a comprehensive escalation-of-force toolkit.

Because the JNLWP S&T Program direction is guided by the future operational environment and shaped by the actual and anticipated needs and requirements of the Military Services and CCMDs, it is imperative that S&T project managers collaborate with warfighters and combat developers to set expectations for NLW technology development. Early feedback in the S&T development process enables the JNLWP S&T Program to focus on those technology and knowledge products most likely to transition. Similarly, the JNLWP S&T Program must remain engaged with potential Service and other government agency NLW materiel developers to facilitate programmatic and technical hand-off of S&T products for further development or use. To accomplish these objectives, JNLWP S&T project managers frequently participate in relevant Integrated Product Teams, Warfighter Workshops, and technical working groups. By staying closely tied in the with the direction of the DOD NLW Program at large, the JNLWP S&T Program

is able to ensure that Joint investments are maximally effective in helping the DOD to reach its vision of a fully integrated non-lethal competency.

DOD R&E Enterprise

The JNLWP S&T Program is well integrated into the DOD R&E Enterprise, and engages often with other DOD entities to coordinate and collaborate on opportunities for S&T transitions. Below are just a few examples of organizations within DOD with which the JNLWP collaborates:

- DOD Laboratories and Engineering Centers: Laboratories and engineering centers provide a wealth of scientific and engineering expertise. The JNLWP S&T Program sponsors reimbursable research and development at DOD laboratories to address requirements across the breadth of non-lethal capability and technology enabling objectives and compliment contracted efforts. By working with the DOD laboratories, the JNLWP S&T Program is not only able to capitalize on some of their unique capabilities, but it also is able to gain insight and easily leverage other DOD investments that might offer mutual benefits or gain efficiencies. The JNLWP S&T Program has cooperative partnerships and ongoing work with many of the DOD laboratories, including the Naval Surface Warfare Centers; U.S. Army Research, Development and Engineering Command; U.S. Army Aviation & Missile Research, Development & Engineering Center; and Air Force Research Lab.

- Government-Sponsored Not-For-Profit Entities: The JNLWP funds S&T research and development at Federally Funded Research and Development Centers (FFRDCs) and University-Affiliated Research Center Laboratories (UARCs). The DOD has built long-term strategic relationships with these government-sponsored not-for-profit entities to answer mission-critical research, development, engineering and analysis needs that cannot be met as effectively by existing government and contractor resources.

- International Programs: The JNLWP S&T Program also seeks opportunities to augment national expertise with the capabilities of international partners through programs such as the Coalition Warfare Program (CWP) and through partnerships that leverage bilateral agreements, such as through the Combating Terrorism Technology Support Office (CTTSO).

- Other highlighted R&D partners:
    - Combatting Terrorism Technology Support Office (CTTSO) Technical Support Working Group (TSWG)
    - Physical Security Enterprise & Analysis Group
    - Rapid Reaction Technology Office
    - Defense Advanced Research Projects Agency (DARPA)
    - U.S. Army's Rapid Equipping Force (REF)
    - Small Businesses (through the Small Business Innovative Research Program)

NLW R&D Indefinite Delivery, Indefinite Quantity Multiple Award Contract (IDIQ MAC)

The JNLWD, on behalf of the DOD EA, is responsible for planning, programming and overseeing the JNLWP S&T program elements. In that role, the JNLWD has an inherent responsibility to assist the JNLWP in identifying the most efficient and effective approaches for the acquisition of S&T services. To date, the JNLWP acquisition approach for S&T has been relatively scattered and reactionary. The lack of a comprehensive and strategic acquisition approach has contributed to poor fiscal execution and limited the program's ability to stimulate innovation through competition.

One way the JNLWD is addressing this shortfall is through the establishment of a NLW R&D Indefinite Delivery, Indefinite Quantity Multiple Award Contract (IDIQ MAC), a single broad-scope, but non-lethal weapons-focused, research and development contract vehicle. The anticipated benefits of the IDIQ MAC — expected to award in summer 2016 -are to:

- Provide increased flexibility for executing a wide range of R&D technical objectives
- Increase the breadth of expertise readily accessible to work non-lethal technology challenges
- Reduce project initiation timelines and schedule risk

The JNLWD will continue to use flexible contracting vehicle such as the IDIQ to support DOD NLW Program R&D services.

Broad Agency Announcement

While the IDIQ MAC is intended to be the JNLWD's primary vehicle for conducting planned S&T projects, there remains significant value in routinely canvasing the industrial base for new concepts and approaches. This is a time of rapid technological advancement and one way the JNLWP intends to capitalize on those advancements is through a biennial Broad Agency Announcements (BAA). The BAA will put forth some of the most challenging capability and technology objectives to stimulate industry, especially small businesses, and academia and ensure that the JNLWP S&T Program remains on the cutting edge of discovery and emergent research and technology. [21]

Small Business Innovative Research Program

The JNLWP S&T Program leverages the Department of the Navy's Small Business Innovative Research (SBIR) program to augment JNLWP resources supporting relevant and cutting-edge S&T projects. SBIR solicitations that address specific JNLWP STOs are a potential future path in the use of this important funding venue.

[21] Updated information on JNLWP BAAs and other business opportunities can be found on the program's website at http://jnlwp.defense.gov/

Non-Traditional Sources

For several years, the JNLWP S&T Program has been leveraging the Defense Ordnance Technology Consortium (DOTC), a collaborative partnership between the DOD and the National Armaments Consortium. DOTC operates under Other Transaction Agreements (OTA) (Public Law 103-160, Section 845) in the conduct of RDT&E of prototype solutions. DOTC provides the JNLWP an opportunity to annually solicit solutions from the National Armaments Consortium and reach out to non-traditional defense contractors.

Figure7: Distributed Sound and Light Array mounted on a HMMWV

7.0 CONCLUSION

Looking ahead to the DOD NLWs Program's 30th anniversary in 2026, there are possible future operational paradigms the Joint Force will face as it engages across the range of military operations around the globe an example might involve a large natural disaster in the Pacific Command area with forces dispersed across the operational theater. An amphibious force responding to an evolving humanitarian crisis in an ungoverned portion of a megacity in the Pacific area may have to coordinate with Special Forces engaged in Phase 0 operations further inland. As the disparate forces engage with the civilian population, observers in the area have already experienced intermittent surveillance by small unmanned systems, and victims send in the first news reports by their cell phone.

In this scenario, the Joint Force will come to rely on its NLW toolkit to complement traditional weapons in the complex battlespace. The NLW capability acts as an escalation-of-force enabler between 'shouting and shooting.' The only way to ensure that warfighters have the NLW capabilities they need tomorrow, is to invest in the science and technology to meet the requirements today.

The JNLWP, as the only DOD organization focused entirely on NLWs and the human effects knowledge to realize their operability, is vital to that development. The JNLWP STOs were developed to help focus the S&T investment to get a comprehensive NLW capability to the warfighter between now and 2025. The STOs are aligned to the capability requirements established by the Joint Force and shaped to place increased emphasis on those key technologies that are required in an era of limited funding and resources.

The JNLWP S&T Program has also instituted a repeatable S&T process that focuses on communication and collaboration to realize these objectives. The non-lethal stakeholder community encompasses a wide variety of players, all focused on realizing the DOD NLW Vision, who may pull in varying directions based on their respective points of view. This S&T Plan and associated process serves as a complement to Service S&T plans and the wider DOD NLW Enterprise and acts as a guidepost to communicate the goals of the Joint NLW Program S&T investment. In the end, this increased collaboration and communication will lead to innovative and game-changing ideas in the NLWs portfolio.

The publication of this plan is not without risk. By focusing through 2025, it may become irrelevant due to changing strategic circumstances or technological advancements. To mitigate this problem, the JSTSP is intended to be updated in two years' time in line with the JSTSP cycle. In addition, the JNLWP S&T process incorporates multiple opportunities to collaborate and communicate with new stakeholders, who may have innovative ideas that can be funded outside the IDIQ MAC.

ANNEX A: STO MATRICES

STO-C: COUNTER-MATERIEL VEHICLES										
	Near			Mid			Far			
	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
Objective	Demonstrate multi-mission counter-vehicle capabilities to stop or disable vehicles of any size, weight or speed									
Emphasis	Multi-mission short and mid-range capability			Mobile mid-range capability to support convoy operations			Mobile long-range capability to support force application operations			
Metrics	• Tactically transportable systems • Stop individual vehicles • Effects delivered at 175m while stationary • Effects delivered at 50m while on the move			• Mobile systems • Stop individual or few vehicles at once • Effects delivered at 175m while on the move • Tactically relevant duty cycles			• Mobile systems • Stop and disable individual or few vehicles at once • Effects delivered beyond 2,200m while on the move • Tactically relevant duty cycles			

STO-C: COUNTER-MATERIEL SMALL/MEDIUM VESSELS										
	Near			Mid			Far			
	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
Objective	Demonstrate platform-compatible capabilities to stop or disable up to medium-sized vessels									
Emphasis	Short-range small vessel stopping capability from employment vessel in restricted waters or littorals.			Mid-range small or medium vessel stopping capability from employment vessel in restricted waters or littorals.			Long-range small or medium vessel stopping or disabling capability from employment vessel or aircraft in the open ocean.			
Metrics	• Vessel platform compatible • Stop individual small surface vessels • Effects delivered at greater than 100m			• Vessel platform compatible • Stop multiple small or medium surface vessels • Effects delivered at greater than 500m			• Vessel or aircraft platform compatible • Stop or disable multiple small or medium surface vessels • Effects delivered at greater than 1,000m • Effective up to sea state 3			

STO-C: COUNTER MATERIEL UNMANNED SYSTEMS (UXS)										
	Near			Mid			Far			
	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
Objective	Survey the requirements and technology landscape to determine the extent of the JNLWP S&T Program's role in developing solutions for this emerging focus area									
Emphasis	Address a future capability area			N/A			N/A			
Metrics	• Mature strategic objectives, as appropriate, in coordination with relevant stakeholders			N/A			N/A			

STO-C: COUNTER-PERSONNEL – MOVE & DENY										
	Near			Mid			Far			
	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
Objective	Demonstrate capability to move, and/or deny access to multiple, compliant and non-compliant individuals									
Emphasis	Transportable capability with an expanded effective range envelope to compel even the most motivated individuals to move or stay out of an area			Reduction in SWAP-C and advanced targeting/tracking to increase mission mobility			Further reductions in SWAP-C to increase the breadth of mission applicability			
Metrics	• Effective at 300m • Tactically transportable			• Effective at 300m • Tactical vehicle platform compatible • Engage while stationary or on-the-move			• Effective up to 300m • Crew-served or individual system • Engage while stationary or on-the-move			

STO-C: COUNTER-PERSONNEL – SUPPRESS										
	Near			Mid			Far			
	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
Objective	Suppress multiple compliant and non-compliant targets in a confined space									
Emphasis	N/A			Effects in constrained environments where flammability and/or structural integrity are concerns			N/A			
Metrics	N/A			• Safe suppression capacity onboard aviation/maritime platforms • Effective against multiple compliant and non-compliant targets			N/A			

STO-C: COUNTER PERSONNEL – DISABLE										
	Near			Mid			Far			
	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
Objective	Disable individuals									
Emphasis	N/A			Longer distance and duration engagement			Multiple target engagement			
Metrics	N/A			• Effective from 2-100m • 1 minute duration of effect			• Simultaneously effect multiple individuals in a confined space without precise target location information • 1 minute duration of effect			

STO-C: COUNTER-FACILITY										
	Near			Mid			Far			
	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
Objective	Demonstrate capability to temporarily secure a facility or building									
Emphasis	N/A			Coordination with the Military Services and CCMDs to determine the best solutions for force application			Coordination with other non-kinetic effect areas (i.e., Cyber, Electronic Warfare) to provide additional options for achieving desired effects on these targets			
Metrics	N/A			• Conduct exploratory studies and investigate promising technologies for counter facility applications and utility			• Deny exterior access to a facility or vessel • 60 minute duration of effect			

STO-C: COUNTER-EQUIPMENT										
	Near			Mid			Far			
	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
Objective	Disrupt and/or degrade targeted electronics									
Emphasis	Ubiquitous nature of electronics and communications equipment on the battlefield			Mission theatres that involve threat actors utilizing protected facilities such as hospitals and schools			Provide additional options for achieving desired effects on hardened targets			
Metrics	• Affect accessible individuals/targets			• Affect specific facilities			• Affect specific facilities including hardened/military targets			

STO-E: HIGH POWER RADIO FREQUENCY (HPRF) TECHNOLOGY										
	Near			Mid			Far			
	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
Objective	Advance the development of High Power Radio Frequency (HPRF) technology in order to provide more suitable and operationally effective counter-materiel solutions									
Emphasis	Increase system reliability of HPRF technologies			Reduce SWAP-C of HPRF sources			Increase expeditionary and mobile operability			
Metrics	• Advance megawatt class waveguides and rotary joints, innovative dielectrics and insulators • Characterize optimal frequency and peak power requirements for various target sets			• Develop solid state and tunable HPRF sources • Develop validated and verified target models and effectiveness optimization techniques			• Pursue electronically steerable HPRF and a non-line of sight HPRF weapon or payload			

STO-E: mmWAVE ACTIVE DENIAL TECHNOLOGY (ADT)										
	Near			Mid			Far			
	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
Objective	Advance the development of Active Denial/Millimeter Waves (mmWave) technology in order to provide more suitable and operationally effective counter-personnel solutions									
Emphasis	Improve SWAP-C attributes of ADT systems to gain efficiencies and more accurately aim and engage target individuals			Optimize first-generation ADT technologies for more effective short-range (0-500m), and long-range (500-1,000m) capabilities			Investigate the feasibility of man-portable ADT systems			
Metrics	• Develop improved prime (input) power generation, 95 gigahertz mmWave (output) source power generation, system cooling capacity, and novel antenna configurations.			• Develop follow-on solid state and vacuum tube tunable mmWave sources • Investigate mmWave trade space to compare system effectiveness and duty cycles with waveforms other than 95 gigahertz.			• Pursue emerging compact and efficient source technologies • Incorporate mmWave modules alongside other lethal and non-lethal weapons.			

STO-E: HUMAN EFFECTS CHARACTERIZATION										
	Near			Mid			Far			
	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
Objective	Develop and mature predictive models for NLW stimuli									
Emphasis	Support to ongoing technology development efforts			Behavioral response characterization			Future NLW stimuli			
Metrics	• Mature predictive models and surrogates • Develop thermal nociceptor model in support of mmWave trade space investigations.			• Develop predictive behavioral models for non-lethal stimuli			• Develop models and surrogates for future NLW stimuli and technology			

STO-E: SOUND & LIGHT – ESCALATION-OF-FORCE AT A DISTANCE										
	Near			Mid			Far			
	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
Objective	Improve the state of the art for sound and light (S&L) technologies to make them more operationally suitable for moving or denying access to individuals at a distance									
Emphasis	Maturation of technologies to make sound and light more operationally suitable in the maritime domain			Development of more capable and agile technologies			Development of more capable and agile technologies			
Metrics	• Reduce SWAP-C of acoustic drivers • Increase intelligibility of existing technologies • Improve stabilization and targeting • Incorporate optical aid safety mitigation technologies			• Investigate electronic acoustic beam steering • Develop novel acoustic drivers for improved intelligibility • Integrate S&L technologies with other non-lethal or lethal weapon platforms			• Develop man-portable S&L systems for distributed, dismounted operations • Explore novel technologies to transmit intelligible sound through structural barriers			

STO-E: SOUND & LIGHT – FLASH & BANG										
	Near			Mid			Far			
	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
Objective	Improve the state of the art for flash-bang technologies to make them more capable and operationally suitable in all domains									
Emphasis	Development of capabilities suitable for aviation and maritime platforms			Development of capabilities suitable for aviation and maritime platforms			Investigation of novel approaches to provide flash-bang effects			
Metrics	• Investigate non-pyrotechnic flash-bang devices that meet or exceed currently available pyrotechnic flash bang capabilities			• Incorporate non-pyrotechnic flash-bang technology into other weapon form factors			• Develop effects applied from a distance using DE technology • Seek novel technologies to reduce SWAP-C for a grenade sized non-pyrotechnic flash-bang device.			

STO-E: HUMAN-ELECTRO MUSCULAR INCAPACITATION (HEMI)										
	Near			Mid			Far			
	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
Objective	Advance electrical waveforms and delivery methods to increase operational utility.									
Emphasis	Development of methods to project HEMI effects to longer ranges			Investigation of novel approaches to improve effectiveness and broaden operational utility			Development of capabilities to engage multiple individuals at once			
Metrics	• Investigate methods to improve accuracy by controlling propulsion and flight stabilization. • Improve sighting and electrode attachment, while reducing chances of significant injury.			• Research novel electrical waveforms to improve counter-personnel capabilities (e.g., duration of effect).			• Incorporate multiple electro-muscular incapacitation engagement capabilities in a modular form factor. • Develop HEMI projectiles or payloads that can disable or suppress multiple targets in an area.			

ANNEX B: GLOSSARY

Capabilities-Based Assessment (CBA) – The CBA is the Joint Capabilities Integration and Development System analysis process that provides a robust assessment of a specific mission area, or similar bounded set of activities, to assess the capability and capacity of the Joint Force to compete successfully the mission or activities. (source: JCIDS Manual)

Capability – The ability to complete a task or execute a course of action under specified conditions and level of performance. (source: CJCSI 3170.01)

Capability Gaps – The inability to meet or exceed a capability requirement, resulting in an associated operational risk until closed or mitigated. The gap may be the result of no fielded capability, lack of proficiency or sufficiency in a fielded capability solution, or the need to replace a fielded capability solution to prevent a future gap. (source: CJCSI 3170.01)

Capability Requirement –A capability required to meet an organization's roles, functions, and missions in current or future operations. To the greatest extent possible, capability requirements are described in relation to tasks, standards, and conditions in accordance with the Universal Joint Task List or equivalent DoD Component Task List. If a capability requirement is not satisfied by a capability solution, then there is also an associated capability gap. A requirement is considered to be "draft" or "proposed" until validated by the appropriate authority. (source: CJCSI 3170.01)

Collateral Damage – Unintentional or incidental injury or damage to persons or objects that would not be lawful military targets in the circumstances ruling at the time. (source: JP 1-02)

Combat developer – Command or agency that formulates doctrine, concepts, organization, material requirements and objectives. May be used generically to represent the user community role in the materiel acquisition process. (source: DODI 3200.19)

Compliant – A compliant target is one who does not attempt to overcome or resist a non-lethal effect. (source: JNLE CBA)

Confined Space – An area of varying dimensions and size that has limited or restricted avenues to enter, egress or evade engagement. (source: JNLE CBA)

Contingency – A situation requiring military operations in response to natural disasters, terrorists, subversives, or as otherwise directed by appropriate authority to protect U.S. interests. (source: JP 1-02)

Counter-Materiel – Directed effects against materiel (vehicles, vessels, aircraft, buildings, facilities, structures, weapon systems, ammunition, weapons of mass destruction, etc.). Non-lethal counter-materiel effects must remain non-lethal to personnel. (source: DODI 3200.19)

Counter-Personnel – Effects directed against individuals. (source: DODI 3200.19)

Cyberspace – A global domain within the information environment consisting of the interdependent network of information technology infrastructures and resident data, including the Internet, telecommunications networks, computer systems, and embedded processors and controllers. (source: JP 1-02)

Cyberspace Operations – The employment of cyberspace capabilities where the primary purpose is to achieve objectives in or through cyberspace. (source: JP 1-02)

Cyberspace Superiority – The degree of dominance in cyberspace by one force that permits the secure, reliable conduct of operations by that force, and its related land, air, maritime, and space forces at a given time and place without prohibitive interference by an adversary. (source: JP 1-02)

Deny – An action to hinder or prevent the use of space, personnel, or facilities. (source: DODD 3000.03E)

Department of Defense Executive Agent (DOD EA) – The Head of a DOD Component to whom the Secretary of Defense or the Deputy Secretary of Defense has assigned specific responsibilities, functions, and authorities to provide defined levels of support for operational missions, or administrative or other designated activities that involve two or more of the DOD Components. (source: DODD 5101.1)

Department of Defense (DOD) Non-Lethal Weapons (NLW) Program – DOD efforts related to research, development, test, evaluation, procurement, deployment, and employment of NLWs, regardless of funding source or effort management. (source: DODD 3000.03E)

Deterrent Options – A course of action, developed on the best economic, diplomatic, and military judgement, designed to dissuade an adversary from a current course of action or contemplated operations. (source: JP 1-02)

Directed Energy – An umbrella term covering technologies that relate to the production of a beam of concentrated electromagnetic energy or atomic or subatomic particles. Also called DE. (source: JP 1-02)

Directed-Energy Device – A system using directed energy primarily for a purpose other than as a weapon. (source: JP 1-02)

Disable – To render ineffective or unable to perform. (source: DODD 3000.03E)

Divert – To turn aside from a course or direction. (source: DODD 3000.03E)

Domestic Emergencies – Civil defense emergencies, civil disturbances, major disasters, or natural disasters affecting public welfare and occurring within the United States and its territories. (source: JP 1-02)

Effect – The physical or behavioral state of a system that results from an action, set of actions, or another effect; the result, outcome, or consequence of an action; a change to a condition, behavior, or degree of freedom. (source: DODI 3200.19)

Effectiveness – The extent to which specific NLW achieve the intended effect. (source: DODI 3200.19)

Electromagnetic Interference – Any electromagnetic disturbance, induced intentionally or unintentionally, that interrupts, obstructs, or otherwise degrades or limits the effective performance of electronics and electrical equipment. (source: JP 1-02)

Electromagnetic Jamming – The deliberate radiation, reradiation, or reflection of electromagnetic energy for the purpose of preventing or reducing an enemy's effective use of the electromagnetic spectrum, and with the intent of degrading or neutralizing the enemy's combat capability. (source: JP 1-02)

Electromagnetic Spectrum – The range of frequencies of electromagnetic radiation from zero to infinity. It is divided into 26 alphabetically designated bands. (source: JP 1-02)

Electronic Warfare – Military action involving the use of electromagnetic and directed energy to control the electromagnetic spectrum or to attack the enemy. (source: JP 1-02)

Expeditionary Force – An armed force organized to accomplish a specific objective in a foreign country. (source: JP 1-02)

Human Effects Review Board (HERL) – A measure of the availability, sufficiency and maturity of human effects knowledge regarding a specific NLW. (source: DODI 3200.19)

Human Effect – The physical impact on, or behavioral response of, a human resulting from a stimulus or set of stimuli. (source: DODI 3200.19)

Human Effects Characterization – A formal process for fully describing the compendium of physiological- and behavioral-effects knowledge associated with a given NLW. It establishes the baseline human effects understanding of NLWs, identifies risk and data gaps in human effects knowledge, and facilitates presentation and communication of its human effects. (source: DODI 3200.19)

Incapacitate – To disable, inhibit, or degrade one or more functions or capabilities of a target to render it ineffective. (source: DODI 3200.19)

Information Operations – The integrated employment, during military operations, of information-related capabilities in concert with other lines of operation to influence, disrupt, corrupt, or usurp the decision-making of adversaries and potential adversaries while protecting our own. Also called IO. (source: JP 1-02)

Initial Capabilities Document (ICD) – The purpose of an ICD is to document capability requirements and associated capability gaps in cases where the sponsor deems the operational risk of unmitigated capability gaps to be unacceptable. The ICD provides traceability to the operational context and other relevant factors for the capability requirements, quantifies any associated capability gaps and operational risks across the Joint Force based on the identified capability requirements, and proposes materiel and/or non-materiel approaches to closing or mitigating some or all of the identified capability gaps. (source: JCIDS Manual)

Joint Non-Lethal Weapons Program (JNLWP) – Joint efforts related to research, development, test, and evaluation under the oversight of the DOD EA for NLW. (source: DODD 3000.03E)

Littoral – The littoral comprises two segments of operational environment: 1. Seaward: The area from the open ocean to the shore, which must be controlled to support operations ashore. 2. Landward: The area inland from the shore that can be supported and defended directly from the sea. (source: JP 1-02)

Materiel – All items (including ships, tanks, self-propelled weapons, aircraft, etc., and related spares, repair parts, and support equipment, but excluding real property, installations, and utilities) necessary to equip, operate, maintain, and support military activities without distinction as to its application for administrative or combat purposes. (source: JP 1-02)

Materiel Developer – A command or agency responsible for research and development, production, and fielding of a new materiel system. (source: DODI 3200.19)

Measure of Effectiveness – A criterion used to assess changes in system behavior, capability, or operational environment that is tied to measuring the attainment of an end state, achievement of an objective, or creation of an effect. (source: SMC Systems Engineering Handbook)

Move – To go or pass to another place or in a certain direction with a continuous motion. (source: JNLE CBA)

National Defense Strategy – A document approved by the Secretary of Defense for applying the Armed Forces of the United States, in coordination with Department of Defense agencies and other instruments of national power, to achieve national security strategy objectives. Also called NDS. (source: JP 1-02)

Natural Disaster – An emergency situation posing significant danger to life and property that results from a natural cause. (source: JP 1-02)

Non-Compliant – A non-compliant target is one who exhibits passive resistance, active resistance, aggression, and/or assaultive behavior in response to a NLE or is otherwise unaffected/unaware of a NLE. (source: JNLE CBA)

Non-Lethal Weapons (NLWs) – Weapons, devices, and munitions that are explicitly designed and primarily employed to incapacitate targeted personnel or materiel immediately, while minimizing fatalities, permanent injury to personnel, and undesired damage to property in the target area or environment. NLWs are intended to have reversible effects on personnel and materiel. (source: DODD 3000.03E)

Non-lethal Technology – Technology being considered or utilized as a NLW. (source: DODI 3200.19)

Open Space – Any area large enough to allow a target, relative to its size, unlimited avenues to enter, egress, or evade engagement (e.g., fields, rural roads and deserts). (source: JNLE CBA)

Permanent Injury – Physical damage that permanently impairs physiological function that restricts employment or other activities of a person for the rest of his or her life. (source: DODD 3000.03E; DODI 3200.19)

Reversibility – The ability to return the target to its pre-engagement functionality, usually measured by the time and level of effort required for recovery of the target. (source: DODI 3200.19)

Riot Control Agent – Any chemical, not listed in a schedule of the Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction, which can produce rapidly in humans sensory irritation or disabling physical effects that disappear within a short time following termination of exposure. (source: JP 1-02)

Risk of Significant Injury (RSI) – The potential of a NLW to cause direct injury requiring HCC Index 1 or higher HCC index treatment, permanent injury, or death. RSI is the parameter used to describe reversibility of a NLW as it relates to human effects. (source: DODI 3200.19)

Rules of Engagement (ROE) – (DOD) Directives issued by competent military authority that delineate the circumstances and limitations under which United States forces will initiate and/or continue combat engagement with other forces encountered. (source: JP 1-04)

Significant Injury – Injury requiring health-care capability index 1 (first responder-capability including resuscitation, stabilization, and emergency care) or higher index treatment. (source: DODD 3000.03E)

Suppress – To degrade the ability of an individual to take specific action. (source: DODD 3000.03E)

Target – An area, complex, installation, force, equipment, capability, function, or behavior identified for possible action to support a commander's objectives, guidance, and intent. (source: DODI 3200.19)

ANNEX C: ACRONYM LIST

ADS – Active Denial System
ADT – Active Denial Technology
ARDEC – U.S. Army Armament Research, Development and Engineering Center
ARCIC – Army Capabilities Integration Center
BA – Budget Activity
BAA – Broad Agency Announcements
BBP – Better Buying Power
CBA – Capabilities-Based Assessment
CM – Counter-Materiel
CMC – Commandant of the Marine Corps
COCOM – Combatant Command
COI – Communities of Interest
CP – Counter-Personnel
CWP – Coalition Warfare Program
DE – Directed Energy
DOD – Department of Defense
DOD EA– Department of Defense Executive Agent
DODD – Department of Defense Directive
DODI – Department of Defense Instruction
DHS – Department of Homeland Security
DOTC – Defense Ordnance Technology Consortium
DSLA – Distributed Sound and Light Array
DS TAT – Defense Systems Technical Area Tasks
DTIC – Defense Technical Information Center
EC&P – Emerging Capability and Prototyping
ED&A – Experimentation, Demonstration, and Assessment
EO – Electro-optical
EW – Electronic Warfare
FY – Fiscal Year
FYDP – Future Year Defense Program
HCC – Health Care Capability
HE – Human Effects
HEMI – Human Electro-Muscular Incapacitation
HERB – Human Effects Review Board
HPM – High Power Microwaves
HPRF – High Power Radio Frequency
ICD – Initial Capabilities Document
IDIQ MAC – Indefinite Quantity Multiple Award Contract
IO – Information Operations
IR – Infrared
IR&D – Independent Research and Development
IW – Irregular Warfare

JCTD – Joint Capability Technology Demonstration
JNLE – Joint Non-lethal Effects
JNLWD – Joint Non-Lethal Weapons Directorate
JNLWP – Joint Non-Lethal Weapons Program
JSTSP – Joint Non-Lethal Weapons Program Science and Technology Strategic Plan
MCWL – Marine Corps Warfighting Laboratory
mm – Millimeter
mmWave – Millimeter Waves
NATO – North Atlantic Treaty Organization
NLW – Non-Lethal Weapons
NLE – Non-Lethal Effects
NMS – National Military Strategy
NSS – National Security Strategy
NSWC – Naval Surface Warfare Center
OASIS – One Acquisition Solution for Integrated Services
OTA – Other Transaction Agreements
PR – Program Reviews
QDR – Quadrennial Defense Review
R&D – Research and Development
R&E – Research and Engineering
RF – Radio Frequency
ROE – Rules of Engagement
RSI – Risk of Significant Injury
S&T – Science and Technology
SBIR – Small Business Innovation Research
SCADA – Supervisory Control and Data Acquisition
SOCOM – Special Operations Command
SOF – Special Operations Forces
STOs – Science and Technology Objective
STO-C – Science and Technology Objective Capability
STO-E – Science and Technology Objective Enabler
STTR – Small Business Technology Transfer Program
SWAP-C – Space, Weight, Power, and Cooling
T&E – Testing and Evaluation
TR – Technical Reviews
UAS – Unmanned Aircraft System

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