Innovation of Non-Lethal Weapons

The human effects modeling and analysis program

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The DOD Non-Lethal Weapons Program stimulates and coordinates non-lethal weapons requirements of the U.S. Armed Services and allocates resources to help meet these requirements. The Commandant of the Marine Corps serves as the DOD Non-Lethal Weapons Program Executive Agent, facilitating experimentation, development, transition, and fielding of non-lethal capabilities to achieve counterpersonnel and countermateriel objectives with scalable and relatively reversible effects.

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In Afghanistan, Marines fired 40mm non-lethal munitions at local nationals stealing equipment, impacting one and causing all to flee, without significant injuries. Marines avoided one or more bad outcomes, having a capability, intended to minimize injuries and fatalities. Determining a non-lethal weapon's human effects—and how well they minimize injuries and fatalities—has been an important aspect of their development in the DOD for two decades.

In May 2015, the U.S. government was asked to do more regarding non-lethal weapons, or "less-than lethal weapons" as it is commonly called in law enforcement. "Relevant federal agencies, including the U.S. Departments of Defense and Justice, should expand their efforts to study the development and use of new less than lethal technologies," stated the *Final Report of the President's Task Force on 21st Century Policing* (Washington, DC: May 2015). Such expanded development of non-lethal weapons can be enabled by a DOD initiative called the Human Effects Modeling and Analysis Program.

Increasing Demand Signals for Non-lethal Weapons

For security forces operating in the midst of a civil populace, lethal force doesn't work in all situations. U.S. forces found that, by itself, lethal force did not stop looting in Somalia. Moreover, it's critical that casualties are not caused within the civil population, as the consequences can be devastating. After security forces fired into a rioting Afghan crowd in 2006 following a fatal traffic accident involving a military truck, protests broke out in Kabul.

There is a need for non-lethal weapons to fill the gap between warnings and lethal force. Non-lethal weapons are designed with the intent of producing reversible human effects that influence behaviors in a particular manner but minimize fatalities and significant injuries—those requiring major medical care to treat and reverse. As just a few examples, such non-lethal weapons include:

- Taser-like devices, causing electromuscular incapacitation that disrupts a targeted individual's actions.
- Millimeter wave energy that causes an intense heating sensation, thus repelling individuals from areas.
- Munitions producing blunt trauma that degrades behavior and activities like rock throwing.
- Flash-bangs, producing light and sound, that also degrade behaviors and activities.
- Lasers that get individuals' attention as well as temporarily degrade visual capabilities.

And, non-lethal weapons have provided force options, between warnings and lethal, also preventing casualties within the civil populace. In Iraq, one Marine battalion used pepper spray to disperse crowds that were angry because of delayed fuel trucks. "Many Iraqi lives were saved as a direct result of 2/8's employment of NLW/C (non-lethal weapons/capabilities)," stated the Commander, 2nd Bn, 8th Marine Regiment (Colonel Royal Mortenson, USMC, "Nonlethal Weapons/Capabilities Interview Questionnaire," 17 August 2005).

The demand signals for non-lethal weapons are growing. In recent years,

this demand is represented in multiple DOD reports/studies; repeated statements in Congressional language and acts; a Department of State report on Benghazi attack; many NATO studies; a U.N. Study on Peacekeeping; and, the latest, *The President's Task Force on 21st Century Policing.* But, the biggest demand comes from those armed only with lethal force and facing desperate situations. "If you want non-lethal effects, give us non-lethal tools," said one soldier in Afghanistan, and many want non-lethal weapons that can do more than those that exist today.

Focus on Human Effects

Important to meeting these demands will be an understanding of a non-lethal weapon's human effects early in development. Requirements writers must specify the desired human effects that users need from a non-lethal weapon. Developers must know the needed human effects so that they can build a system to those specifications. Test and evaluators must know them and understand how to best test them.

And users especially need knowledge of non-lethal weapons. Commanders must understand all aspects of a non-lethal weapon. Warfighters need to know some aspects but must firmly understand its effectiveness, advantages provided, and degree of confidence they can have in its capability and reliability.

For a long time, determining desired and undesired human effects of non-lethal stimulus was especially challenging. For example, millimeter wave energy was known to raise skin temperature, causing targeted individuals to move away from it. But, the questions were: how much was needed to cause that effect, how much would cause significant thermal injuries, and under what conditions do those intended and unintended human effects occur? The answers took years to determine, made difficult by the fact that such stimuli cannot be readily and fully tested on humans.

Predicting Human Effects: The HEMAP

To help non-lethal weapons programs, DOD's Non-lethal Weapons Program initiated the Human Effects Modeling and Analysis Program (HEMAP) in 2007. The program is customer focused, its customers being the Services and agencies' non-lethal weapons program managers. It is a series of projects and science and technology investments that develop capabilities, predicting human effects for stimuli, thus aiding non-lethal weapons development and use.

Predictive capabilities are only as good as the data on which they are based. Thus, the HEMAP rigorously collects data from sources of human effects research, in some cases conducted over decades. For example, data on human responses to blunt impact can be traced to research in the 1990s and perhaps earlier. The Program also has made science and technology investments to collect data, filling gaps in predictive capabilities. It's then sponsored-applied research to build those models.

Today, the HEMAP has a suite of models that predict human effects for a range of stimuli, which can aid non-lethal weapons programs in develop-

A U.S. Marine engages an unknown driver of a vehicle with an LA-9/P optical distractor during escalation-of-force procedures. Non-lethal optical distractors, also known as dazzling lasers, have undergone legal reviews to ensure compliance with obligations assumed by the U.S. under applicable treaties, customary international law, and the law of armed conflict. The design and use of optical distracters has many years of eye-safety research that, through engineering and training, ensures these devices can be used both effectively and with minimal risk of injury. ***(DoD photo by Robert B. Hinton.)***

ment and use. These models predict human effects for the following:

Blunt impact from non-lethal projectiles. The model predicts a variety of injuries to skin, head, eyes, chest, abdomen, and extremities. The model also can improve projectile design.

Thermal effects. Such as those caused by blast munitions and directed energies, this model predicts when thermal energies produce avoidance effects in targeted individuals. It also predicts when burns occur, specifically, the depth of thermal injuries, and thus first, second, and third degree burns.

Acoustic effects. Like those from flash-bangs and acoustic hailing devices, the model determines probability of temporary and permanent changes in hearing and eardrum rupture.

Overpressure effects to the lungs. These may be from flash-bangs or other blast munitions, particularly in enclosed spaces. Based on pressures around the chest, the model predicts probabilities of varying lung injuries.

Optical effects from light sources. Like those from lasers and flash-bangs, these models predict the impact of optical radiation on visual function such as temporarily obscuring vision as well as optical injuries.

This centralized modeling has several benefits for non-lethal weapons development. First, it standardizes the modeling of non-lethal stimuli. Generally, the HEMAP's models take into account the characteristics of a given stimulus; its projection to a target and, in some cases, probability of hitting the target; interaction with the target; and target responses.

Centralized modeling also helps standardize assessments. Stimuli and their human effects vary, but they can be assessed against general criteria for effectiveness—such as how well each disrupts and degrades actions—as well as against standards for significant injuries. One stimulus may have a higher probability of causing significant injuries requiring major medical care than another.

Additionally, centralized modeling also enables assessment of two or more stimuli, which some non-lethal systems use in a combined manner. For example, the modular crowd control munition employs optical and acoustic effects of a flash-bang as well as disperses blunt impact, sting-balls.

HEMAP Aiding Non-lethal Weapons Development

The HEMAP's models can inform non-lethal weapons development upfront and throughout the process, thus making it faster and less risky than without it. Specifically, these models can enable the following:

Analysis of alternatives. Required early in defense acquisition to identify the best choice for development. Conceivably, the HEMAP's models could assess and compare stimuli for the human effects in a particular operational concept. For example, the HEMAP might determine particular optical and acoustic effects produced by a flash-bang might suppress a specific behavior better than a blunt impact munition.

Reduced risk. Identification of a stimulus and its human effects allows developers to match them against stated non-lethal weapons requirements as well as ask users, "is this what you want?"

Focused research. Human effects research is less likely to be discovering what's already been discovered, and more likely confirming predicted effects and determining conditions, in which they will and won't occur.

Focused development. Once human effects are predicted and confirmed, they become the "goal posts" for technology development. It can focus on building a system that produces such effects, while designing it to avoid the unintended human effects.

Identifying engineering trade space. Development often involves give-and-take between developers and users. For example, a blunt impact projectile may be projected to a required range of 100 meters but cause significant injuries. Users must then decide if they will trade range for reduced risk. The HEMAP's models can help identify this engineering trade space for developers and users.

Developing measures of effectiveness. Predicted and confirmed human effects can not only guide technology and system development but also can contribute to measures of effectiveness needed in their development, operational testing, and mission planning.

Wanted: Customer Needs and More Data

The HEMAP is forward-looking in its efforts to help non-lethal weapons development and acquisition, seeking to know program needs as early as possible. It takes time to build and adapt predictive capabilities to meet those needs. Starting to build a model at the time it's required will often be too late. The program also prioritizes work with testing organizations to determine requirements for verification and validation, mandated in DOD acquisition, to ensure that supporting models are constructed correctly and do what they are intended.

For example, the Marine Corps is pursuing a non-lethal weapons initiative called "disable point target." Using a taser-like electro-muscular incapacitation, this system would temporarily disable personnel for as long as 60 seconds and out to ranges of 100 meters. The HEMAP will try to address the broad requirements for modeling human effects associated with this program.

These non-lethal weapons program requirements inform the HEMAP's strategic planning. This includes making investments that will address gaps in predictive capabilities needed in the future. This planning also sets timelines and objectives to ensure those capabilities are achieved in time to help program managers.

The HEMAP also seeks more data—either from its sponsored research or via relationships with those doing related human effects research. Such data are needed for the continual refinement of existing models. Data are also needed to build new models.

Helping Meet the Demand

The demand for non-lethal weapons is forecasted to grow in the future; as it does, more government agencies and other organizations will attempt to meet it. But, successful development and use of non-lethal weapons must be based on human effects. The HEMAP can help. It has collected much of the past research and developed models that can predict human effects, thus reducing time, cost, and risk in non-lethal weapons development.

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