

## Non-lethal technologies—an overview

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Whilst the focus for this issue of *Disarmament Forum* is on chemical and biological weapons, sight should not be lost of the spectrum of non-lethal technologies that are being deployed or under development. These technologies will have an increasing impact on war fighting, peace support operations, civil policing and prison control. It is our purpose here to briefly review the non-lethal field so that biochemical incapacitating agents can be placed in a broader context. There is an extensive literature associated with non-lethal weapons, and readers are directed to this for more detailed information and discussion.<sup>1</sup> We will only highlight the key characteristics and concerns associated with these non-lethal technologies.

There has been a growing interest in non-lethal weapons over the last decade. It has been argued, and in some cases operationally demonstrated, that non-lethal technologies are particularly useful in conflict situations such as when combatants and non-combatants are mixed together (sometimes deliberately); when there is a requirement for alternatives to lethal methods in military peace support operations; when civil law enforcement agencies and prison services have to manage violent lawbreakers; and for riot control. There has also been increasing pressure to develop methods of being able to fight a “bloodless and humane” war, and increasing resistance by domestic constituencies to accept deaths in war operations. Advances in non-lethal technology have been made possible by additional investment both by governments and private companies, and the fact that many of the technologies have dual-use military/civilian applications. Other factors that have fuelled this attention to non-lethal weapons have been debates concerning the revolution in military affairs and the revolution in military technology.

Some analysts have argued that the term “non-lethal” is a misnomer, and that “less lethal” is a more appropriate and accurate description of the weapons described in this paper. We would agree, of course, that there is no guarantee that any weapon can be 100% non-lethal. But we think that the label “non-lethal” has a useful generic function and that the criteria laid out in our following definition clearly set the parameters to what we would call a non-lethal weapon. Non-lethal weapons are specifically designed to incapacitate people or disable equipment, with minimal collateral damage to buildings and the environment; they should be discriminate and not cause unnecessary suffering; their effects should be temporary and reversible; and they should provide alternatives to, or raise the threshold for, use of lethal force. Existing non-lethal weapons include rubber and plastic bullets, entangling nets, irritant sprays such as pepper or tear gas, and electrical stunning devices such as the “Taser” gun. New non-

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**Table 1. Non-lethal technologies**

Technology	Type(s)	Description	Delivery	Target
Kinetic energy	Impact projectiles	Airfoil; baton (foam, plastic, rubber, sponge, wooden); drag-stabilized (beanbag); encapsulated (water, dye, RCAs, malodorant); fin-stabilized; pads; pellets (single, multiple small/large)	Gun, shotgun, launcher, mortar	AP, AM
	Water cannon	High-pressure jets (may be marked with dye, electrified or have chemical irritant additive)	Vehicle mounted, backpack or fixed-in-place systems	AP
Barriers and entanglements	Nets, chains, spikes	Spikes/strips of spikes, caltrops, barrier to stop vehicles; launched nets to snare people or tangle boat propellers; rigid foams to block windows or doorways	Net launchers; for foam: hand-held, backpack or vehicle mounted tank with spray device	AP, AM
Electrical	Stun weapons	Electrical incapacitation; stun guns, electrical baton, shield, net, water cannon, stun belt, mine/grenade; "wireless" systems under development for use against people or vehicle electronics	From device: either direct contact with electrodes or remotely via wires and barbs; wireless systems will use projectiles with capacitor or pulsed laser for delivery of shock	AP, AM
Acoustic	Acoustic-optical	Flash-bang/stun grenades produce loud noise and bright light	Grenades	AP
	Acoustic generators	Devices that project audible, ultrasonic or infrasonic sound frequencies; may cause pain/discomfort, nausea, disorientation	Acoustic generator devices (fixed, portable or hand-held)	AP
	Vortex generators	Generator that projects a vortex of air at high speed ("acoustic projectile"); may also be used as a carrier of other substances such as chemical agents	Vortex generator devices	AP
Directed energy	High-power microwave (HPM)	Radiofrequency (RF) energy designed to degrade or destroy electronic equipment; electrical or explosive generation of energy	Bomb/missile, fixed or portable device	AM
	Millimetre wave	"Beam" directed at people heats up water molecules in surface of skin causing burning sensation, e.g. "Active Denial System"	Vehicle or aircraft mounted system	AP
	Laser (low energy)	Red and/or green diode lasers to temporarily blind or obscure vision known as "dazzlers" or "illuminators"	Torch-like device (handheld or weapon mounted)	AP
	Laser (high energy)	Chemical laser systems for use against materiel, lethal if used against humans (e.g. "Advanced Tactical Laser"); pulsed chemical lasers to produce "shock wave" to incapacitate people (e.g. "Pulsed Energy Projectile")	Aircraft or vehicle mounted systems under development; desire for handheld systems in the future	AP, AM
Chemical	Riot control agents (RCA)	Irritant chemicals (tear gas) such as CS, CN and CR; OC (pepper spray of biological origin; PAVA is a synthetic version); aerosols or powdered form; cause irritation of eyes and upper respiratory tract	Shotgun cartridges, mortar shells, grenades, and spray devices; frangible projectiles containing powdered RCA fired with launcher or existing gun; airburst munitions under development	AP
	Malodorants	Foul-smelling chemicals used as RCA or to discourage access to an area	As for RCA	AP
	Anti-traction materials (ATM)	Lubricating polymers spread on ground or other surfaces to prevent access by people or vehicles	Backpack or vehicle mounted tank with spray device	AP, AM

Technology	Type(s)	Description	Delivery	Target
Chemical (cont.)	Obscurants	Smokes to obscure vision; dyes for underwater use	Grenades, mortar shells	AP
	Foams	Rigid or sticky foams as a barrier (not for use directly against people because of risk of blocking airways); aqueous foams as personnel barrier (chemical irritants could be added)	Spray devices	AP
	Anti-materiel chemicals	For use against structures or vehicles; combustion modifiers, fuel contaminants, super-corrosives, embrittling agents, super-adhesives and depolymerization agents have been proposed	Direct deployment, spray device, or projectile containing substance	AM
	Defoliant/herbicides	Chemicals to kill crops or vegetation; used in Viet Nam (Agent Orange); dangerous to human health (e.g. cancer causing dioxins in Agent Orange)	Sprayed from aircraft / crop duster	Anti-plant; extreme danger to human health
Chemical / biochemical	Incapacitants <b>Illegal under CWC and BTWC</b>	Toxic chemical or biochemical agents acting on neuroreceptors in the central nervous system to cause sedation, disorientation, hallucination, mood changes, unconsciousness and death; delivered as aerosol; distinct from RCAs	Aerosol delivery directly over an area with an aerosol generator or munitions/projectiles of a similar type to RCAs; also possibility of injection as with sedation darts; other routes (e.g. transdermal) have been suggested	AP
Biological	Anti-materiel micro-organisms <b>Illegal under BTWC</b>	Bacteria that degrade various materials (e.g. plastics, metal, etc.)	Direct application with aerosol spray most likely	AM
	Anti-crop agents <b>Illegal under BTWC</b>	Fungi to kill drug crops such opium or coca plant	Application with aerosol spray, most likely from aircraft/crop duster	Anti-plant
Combined technologies	Combining various non-lethal technologies	Frangible projectiles containing chemicals (kinetic and chemical); laser delivered "wireless" electrical weapons (DE and electrical); modified water cannon (kinetic and chemical/electrical); "multi-sensory grenade" (acoustic-optical and chemical)	Various described above	AP
Delivery systems	Non-lethal munitions	Non-lethal munitions (e.g. mortar shells) to disperse various payloads (aerosol, liquid, solid, powder); airburst munitions	Gun, launcher, mortar	Depends on payload
	Encapsulation / micro-encapsulation	Encapsulation ("paintball"-type projectiles) and micro-encapsulation (minute capsules) for delivery of chemical agents, such as RCAs, malodorants, dyes, and anti-traction materials	Encapsulated projectiles from launcher; micro-capsules from munition or direct application	Depends on payload
	Unmanned vehicles	Aerial vehicles, surface watercraft, underwater vehicles, ground vehicles	Deployed from unmanned platform	Depends on payload

Note: AP = anti-personnel; AM = anti-material

lethal weapons are on the way, which will include acoustic and microwave weapons, non-lethal landmines, and malodorants (see Table 1). Many analysts would agree that there is a "legitimate" role for non-lethal weapons, both for civil and military applications. However there is considerable disagreement as to the operational effectiveness of non-lethal weapons, and the threat such weapons pose to arms conventions and international law. As usual, a balance has to be achieved where the

benign advantages of developing and deploying non-lethal weapons are not outweighed by their more malign effects. In particular, emerging non-lethal technologies offer an increasing opportunity for the suppression of civil dissent and control of populations—these are sometimes referred to as the “technologies of political control”.

### *Emerging technologies*

#### KINETIC ENERGY

Kinetic energy (KE) weapons, such as baton rounds (plastic and rubber bullets), truncheons, shot-filled beanbags, small rubber balls and water cannons, have been used by police and military forces for many years. Despite long experience of operational use, these weapons have their limitations. A US National Research Council<sup>2</sup> report points out that their short range, together with a deteriorating accuracy at longer distances, limits their use to situations of close engagement. Of more concern are safety considerations, and the control of trauma level from blunt projectiles remains a serious problem. Recent developments in KE technology include sophisticated water cannons, for example “... an Israeli version has been developed which fires ‘bullets’ of water, very small quantities of water at high pressure. A variety of configurations exist with some recently developed options enabling ultra-cold slugs of water to be fired, or for the jets to be electrified.”<sup>3</sup> The water can also have a dye added allowing for easy identification of rioters or a chemical irritant. Several types of plastic bullet are in use, including the L21A1 plastic baton round in the United Kingdom, and foam-tipped plastic bullets that have been designed to minimize injuries. The latter were field tested by the US Marine Corps in Iraq but rejected as being ineffectual.

#### BARRIERS AND ENTANGLEMENTS

Vehicle barrier systems currently available include the Portable Vehicle Arresting Barrier and the X-Net (or Vehicle Lightweight Arresting Device, VLAD), which has been successfully used by US Marines in Haiti. The X-Net is made from a strong polyethylene called Dyneema. Nets are also available to capture individuals; these nets can be electrified or have sticky substances added to them. Current research into new barrier systems includes work based on the principles of gas-generated airbags.<sup>4</sup> Researchers are looking into the use of spider silk as a non-lethal “entanglement” material for disabling people; a method for producing large quantities of recombinant spider silk protein using *E. coli* is being developed.<sup>5</sup> The Running Gear Entanglement System (RGES) is a net deployed to stop propeller-driven watercraft that is in use with the US Coast Guard.

#### ELECTRICAL

Electrical weapons include stun guns, stun batons, electrified shields, electrified nets, electrified water cannon, “sticky shockers”, stun belts, landmines and grenades. Amnesty International has identified manufacturers of electro-shock weapons in twelve countries<sup>6</sup> and their list indicates the largest group of manufacturers being located in Taiwan, China, South Korea and the United States. Probably the best known electrical gun is the Taser, which fires out two barbs attached to fine wire. These catch in

the clothing or skin of the target and an incapacitating electrical shock is administered. Concerns have been raised about the safety and abuse of Taser guns including: its potential use for torture and other human rights violations;<sup>7</sup> that some people are more vulnerable to serious injury or death; and that adequate rigorous medical research related to the safety of the more powerful Tasers has not been carried out.

The safety evaluations of weapons are often produced by the manufacturers themselves and independent scientific research and evaluation is scarce. In the United Kingdom, the Defence Science and Technology Laboratory carried out an assessment of the medical effects of the M26 Taser and, although they concluded from the available literature that the risk of death or serious injuries appeared to be low, they noted that:

The body of manufacturers' experimental evidence from biological models of the hazardous and intended effects of Taser on excitable tissues is not substantial, particularly with regard to the M26; the peer-reviewed evidence is even more limited.<sup>8</sup>

Several companies are developing weapons that can deliver incapacitating shocks without the need for wires. Some of these are essentially combination directed energy/electrical weapons. The underlying principle is to use a laser beam to produce an ionized gas or plasma through which an electrical charge can be conducted to the target person or vehicle. The "Close Quarters Shock Rifle" (CQSR) is one such prototype weapon. The company claims that it "will be able to fire a stream of electricity like water out of a hose at one or many targets in a single sweep".<sup>9</sup> The CQSR bought a swift response from human rights organizations, such as Amnesty International, who again highlighted the fact that, in their view, inadequate research has been carried out on the potential biomedical and psychological effects of such a weapon. There is also a danger of innocent bystanders being affected when such an "indiscriminate" weapon is used.

Wireless electrical projectiles are also being designed to get round the range limitations of the Taser (around six metres) and offer the increased "stand-off capability" that military and police desire. But, as with all projectiles, there is still the problem of decreased accuracy at longer ranges, and this means that people are more likely to be struck in unintended places such as the head and neck. It is also unclear how the projectiles will cause electrical incapacitation. The Taser, for example, can only remain effective whilst the trigger is held down and the electrical current flowing into the body is maintained. Some questions remain: what will be the duration of electrical incapacitation? If it is only momentary does it confer any advantage? If it lasts longer, will the need for increased electrical shock incur increased health risks?

## ACOUSTIC

Acoustic weapons, employing audible sound, infrasound or ultrasound represent one emerging non-lethal technology that is beginning to mature. In the audible range, one company has developed High Intensity Directed Acoustic (HIDA) devices such as the Long Range Acoustic Device (LRAD), designed to deliver audible warning messages over long ranges (up to 1km). However, at closer distances it is considerably more incapacitating and can produce 120db of sound at 60m and peak levels of 130db at 4 metres.<sup>10</sup> Hearing damage can occur at levels as low as 80db if exposure is over a long period, and at levels of 120db and over there is potential for hearing loss even after very short exposures.<sup>11</sup> In addition to ear pain, reportedly some HIDA devices can cause such side effects as loss of equilibrium, vomiting and migraines.<sup>12</sup> A prototype hand-held system based on the same technology,

the “directed stick radiator”, has also been demonstrated. It fires high intensity “sonic bullets” or pulses of sound between 125–150db for a second or two. Such a weapon could, when fully developed, have the capacity to knock people off their feet. It has been argued that weapons that utilize infrasonic frequencies can cause nausea, disorientation and bowel spasms. A mobile “infrapulse generator” is being developed that generates low-frequency shock waves that resonate with body organs and that can cause physical damage. The LRAD was acquired by the US Marines for use in Iraq<sup>13</sup> and there have been reports that an acoustic device has also been used in Afghanistan.<sup>14</sup> The New York Police Department acquired two units in the run up to the 2004 Republican Convention in the city. Again, some analysts have voiced concern that “the U.S. is making a serious mistake by trying to quietly deploy a new pain-inducing weapon without first airing all of the legal, policy and human rights issues associated with it”.<sup>15</sup>

## DIRECTED ENERGY

There are several types of directed energy (DE) weapons under development for non-lethal weapons purposes that employ different sorts of electromagnetic energy: millimetre wave, high-power microwave, low-power diode laser, or high-energy chemical laser. Most are under development and still to be deployed, but there are indications that a new generation of weapons will soon enter into use. The use of DE for non-lethal weapon purposes is only one aspect of a larger “vision” held by the US Department of Defense, which is to exploit the military potential of DE to achieve asymmetric advantage over adversaries. The majority of investment is directed to lethal systems, most notably the Boeing 747-mounted Airborne Laser for missile defence, which has received around US \$2 billion in

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funding.<sup>16</sup> The US Marine Corps *Joint Concept for Non-Lethal Weapons* emphasized the need for a non-lethal to lethal “rheostatic capability”<sup>17</sup> and it has been argued that “... the ideal NLW [non-lethal weapon] would be a system with continuously visible intensity and influence, ranging from a warning tap to a stunning blow to a lethal effect.”<sup>18</sup>

Directed energy is seen as the most promising opportunity to develop a “tuneable” weapon akin to the oft-cited, but fictional, Star Trek Phaser.

The Active Denial System (ADS) is a weapon that uses millimetre wave energy to heat up water molecules in the subcutaneous layers of the skin, causing a painful burning sensation. The radiation acts in a dose-dependent manner and so exposure duration is critical in terms of safety.<sup>19</sup> The US Army has exhibited a Humvee-mounted prototype, which will be given to the armed forces for evaluation before a decision on deployment expected by the end of 2005.<sup>20</sup>

High-power microwave (HPM) weapons deliver a burst of radio-frequency energy designed to degrade or destroy the circuits of electronic equipment. There are two main types of HPM weapons: wide-band weapons that release a burst of radiation over a broad frequency range generated by a high explosive or an electromagnetic generator; and narrow-band weapons that are electrically driven and are directed at specific targets.<sup>21</sup> Concern has been expressed over their potential for destruction of civilian electronic infrastructure—including hospital equipment and heart pacemakers—that would be in contravention of international humanitarian law. HPM weapons have not been described by the military as “non-lethal” and can be seen as an extension of lethal force. For example, a recent US Army announcement called for proposals to enhance the lethality of conventional munitions with a

HPM directed energy component.<sup>22</sup> Other applications for HPM weapons include their potential for stopping vehicles by disabling onboard computer control systems.

Laser weapons include low- and high-power systems. Devices called “illuminators” or “dazzlers”, which are already available, use a low-power diode laser to temporarily blind or obscure vision. There are worries over eye safety in relation to these devices. High-energy lasers are also being investigated for non-lethal applications. For example, the Advanced Tactical Laser is a chemical laser system being developed by the US military, which would be lethal if used against humans. Planned anti-materiel non-lethal uses include “... bursting automobile tires, rupturing fuel tanks, selectively cutting through electrical or communications lines, or setting fires”.<sup>23</sup> Some types of high-energy laser are also under consideration for anti-personnel purposes. One such weapon in the early stages of development is the Pulsed Energy Projectile (PEP), the effects of which have been described as follows:

PEP would utilize a pulsed deuterium-fluoride (DF) laser designed to produce an ionized plasma at the target surface. In turn, the plasma would produce an ultrasonic pressure wave that would pass into the body, stimulating the cutaneous nerves in the skin to produce pain and induce temporary paralysis.<sup>24</sup>

#### RIOT CONTROL AGENTS AND MALODORANTS

Riot control agents (RCAs) include synthetic chemicals CS, CN, and CR as well as Oleoresin Capsicum (OC) or “pepper spray”, which is biological in origin. RCAs are defined in the US Army's *Textbook of Military Medicine* as follows:

Riot control agents are compounds that cause temporary incapacitation by irritation of the eyes (tearing and blepharospasm), causing them to close, and irritation of the upper respiratory tract. They are often called irritants, irritating agents, and harassing agents; the general public usually calls them tear gas.<sup>25</sup>

PAVA, a synthetic version of OC, has become more popular for use in law enforcement since it is more potent than the natural product. There are a variety of shells, grenades and spray devices for delivering RCAs and recent weapons development has focused on new methods of delivery such as the paintball-type PAVA, OC or CS powder-filled projectiles fired by the PepperBall System or the FN 303 launcher. The UK Defence Science and Technology Laboratory are developing a frangible projectile called the Discriminating Irritant Projectile containing powdered CS.

There is concern over the desire of the United States to use RCAs outside of permitted law enforcement applications. In the run up to the war in Iraq, Secretary of Defense Donald Rumsfeld testified to the US Congress House Armed Services Committee, admitting that the US was attempting to “fashion rules of engagement” to enable their use.<sup>26</sup> Subsequently President Bush authorized their use in Iraq in certain circumstances, and CS and pepper spray were shipped to the Gulf. This is legal in US law under Executive Order 11850, which was signed by President Ford in 1975 and permits the use of RCAs under specific conditions such as in “riot control situations in areas under direct and distinct US military control, to include controlling rioting prisoners of war” and in “situations in which civilians are used to mask or screen attacks and civilian casualties can be reduced or avoided”.<sup>27</sup> However, it is illegal under international law. Article I of the 1993 Chemical Weapons Convention (CWC) clearly states “Each State Party undertakes not to use riot control agents as a method of warfare”.<sup>28</sup> RCAs do not appear to have been used in the Iraq conflict but such an intention is a serious threat to the international prohibition against the use of chemicals in war.

Malodorants are foul-smelling chemical compounds that are seen as having potential use for controlling crowds, clearing facilities and area denial. The US military do not consider the development of malodorants to be restricted by the Chemical Weapons Convention:

Malodorants are not considered toxic chemicals, since they do not cause—or are not specifically designed to cause—death, temporary incapacitation, or permanent harm to humans or animals.<sup>29</sup>

However, a Council on Foreign Relations report on non-lethal weapons stated that malodorants are “probably also classed as riot control agents” and could not therefore be used in warfare.<sup>30</sup> From a policing standpoint, a recent UK government report stated that “... malodorants do not appear to offer any tactical advantage over existing incapacitants already available to the police”.<sup>31</sup>

### ***Biochemical incapacitating agents***

One of the most controversial areas of non-lethal weapons research and development is that related to incapacitating agents, which have also been called “calmatives”, “knock-out gas” or “immobilizing agents”. They are distinct from RCAs due to their mechanisms of action. RCAs are chemicals that cause *local* irritation to the eyes and other mucous membranes. Incapacitating agents,

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on the other hand, have *central* effects, acting on cell receptors in the central nervous system to produce various effects including sedation, disorientation, unconsciousness and death. The boundaries of chemistry and biology become blurred in this area since substances that can exert influence by action on specific cell receptor sites can have either a synthetic chemical origin (i.e. toxic chemicals/drugs) or a natural biological origin (i.e. bioregulators).<sup>32</sup> Wheelis has termed these substances potential *biochemical weapons*.<sup>33</sup>

### LEGAL ISSUES

These weapons agents fall somewhere in between “traditional” chemical agents (nerve, blood and blister agents) and “traditional” biological agents (bacteria, viruses and rickettsia). In this context Pearson’s Chemical-Biological Weapons Spectrum is a useful concept (see Table 2).

For toxic agents in the mid-spectrum there is overlap between the legal prohibitions of the CWC and those of the Biological and Toxin Weapons Convention (BTWC). Synthetic chemicals such as the fentanyl derivative used by authorities during the 2002 Moscow theatre siege would fall into the theoretical “Industrial Pharmaceutical Chemicals” category and, as toxic chemicals, are covered by the CWC alone. However the superficial boundaries between this category and that of “Bioregulators” and “Toxins” are blurred. As Wheelis points out, the analogues of bioregulators and toxins are covered by the BTWC. He argues, therefore, that synthetic chemical analogues (i.e. drugs) that bind to the same specific cell receptor sites in the body as the corresponding natural ligands (i.e. bioregulators) are also covered. The significance of this “double coverage” is that would-be developers of such agents should not be able to exploit the loophole in the CWC that permits the use of certain chemicals for “law enforcement including domestic riot

**Table 2. The chemical-biological weapons spectrum**

Classical CW	Industrial Pharmaceutical Chemicals	Bioregulators Peptides	Toxins	Genetically modified BW	Traditional BW
Cyanide Phosgene Mustard Nerve agents	Aerosols	Substance P Neurokinin A	Saxitoxin Ricin Botulinum toxin	Modified/tailored bacteria and viruses	Bacteria Viruses Rickettsia Anthrax Plague Tularaemia
← Chemical Weapons Convention →			← Biological and Toxin Weapons Convention →		
← Poison →			← Infect →		

Source: G. Pearson, 2002, "Relevant Scientific And Technological Developments For The First CWC Review Conference: The BTWC Review Conference Experience", *CWC Review Conference Paper No. 1*, Department of Peace Studies, University of Bradford.

control purposes". This is particularly important given conflicting interpretations of both the CWC's definition of RCAs and its provisions on the acceptable situations for use of such agents.

LETHALITY

Currently available incapacitating agents and associated delivery systems cannot be termed RCAs, which are defined by the CWC as:

Any chemical not listed in a Schedule, which can produce rapidly in humans sensory irritation or disabling physical effects which *disappear* within a short time following termination of exposure.<sup>34</sup> [emphasis added]

The reversibility of effects, with no permanent deleterious change to the victim may be seen as a key aspect of any non-lethal weapon targeted at humans. However, a model developed by Klotz et alia suggests that no existing agents would be able to perform this role.<sup>35</sup> New compounds are likely to present similar problems. If a compound is extremely potent it will tend to have a poor safety ratio. If a compound has a good safety ratio it will tend to have a long onset time or not be sufficiently potent. The former problem was devastatingly illustrated when Russian authorities ended the Moscow theatre siege using an aerosolized fentanyl derivative, most likely carfentanyl,<sup>36</sup> and at least 120 of the 800 hostages died as a result of exposure to the agent, whose major side effect is respiratory depression. Even with an "ideal" compound (high safety ratio and high potency), there would be significant obstacles to "non-lethality", that is the delivery of an effective but safe dose to all individuals in a given area, notwithstanding the differences in age, size and health and the problems of uneven concentrations and cumulative intake of agent.<sup>37</sup>

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SCIENCE AND TECHNOLOGY

Neurotransmitters mediate chemical transmission in the nervous system through their interactions with specific receptors. In the central nervous system these neurotransmitter-receptor interactions have a major role in regulating consciousness, mood, anxiety, perception and cognition. Table 3 gives some of the clinical effects of neurotransmitters.

Neurotransmitters are of primary interest for this discussion because their sites of action, i.e. neuronal receptors, are the exact targets of proposed “non-lethal” incapacitating agents. One study examining potential “calmatives” defined them as “compounds known to depress or inhibit the function of the central nervous system”—suggesting that these might “include sedative-hypnotic agents, anesthetic agents, skeletal muscle relaxants, opioid analgesics, anxiolytics, antipsychotics, antidepressants and selected drugs of abuse”.<sup>38</sup>

The same study recommended that partnerships be formed between weapons developers and the pharmaceutical and biotechnology industries to identify new incapacitating agents. There is already

**Table 3. Neurotransmitters and their clinical effects**

Bioregulator category	Agent	Clinical effects
Neurotransmitters	Catecholamines	Consciousness, mood alterations, anxiety, hypertension, tachycardia, sexual dysfunction
	Amino acids	Effects on learning, memory, cognition, pain sensitivity
	Neuropeptides	Effects on cognition, sensory processing

Source: E. Kagan, 2001, “Bioregulators as Instruments of Terror”, *Clinics in Laboratory Medicine*, vol. 21, no. 3, pp. 607–18.

a significant research focus in the pharmaceutical industry to develop more effective drugs to treat a variety of mental illnesses, and many of the receptor targets are the same as those of interest to incapacitant developers. In addition, there have been considerable advances in recent years of techniques for discovery of new compounds.

MILITARY AND LAW ENFORCEMENT INTEREST

Military interest in incapacitants has a long history. The glycolate agent BZ was weaponized by the US in the 1960s as part of its chemical weapons programme, and there are reports that the Former Soviet Union developed a derivative of BZ as an incapacitating weapon. Iraq’s chemical weapons programme is thought to have incorporated a glycolate compound known as Agent 15. Biological agents have also been considered for use as incapacitating rather than lethal weapons.<sup>39</sup>

In the US, military research in this area is co-ordinated by Joint Non-Lethal Weapons Directorate (JNLWD) and there have been recommendations for increased research on incapacitants, or “calmatives”, and their delivery systems.<sup>40</sup> Objectives listed in the JNLWD’s Technology Investment Project for “Front End Analysis of Non-Lethal Chemicals” for the fiscal year 2001/02 included the need to “... identify advances in the pharmaceutical industry and elsewhere for potential non-lethal applications; conduct military user workshops to identify range of desired operational effects; create a searchable database of potential candidates; provide a list of promising candidates to Judge Advocate General’s office for preliminary legal review.”<sup>41</sup>

In relation to calmatives, the Pentagon’s Defense Science Board in their 2004 task force report on *Future Strategic Strike Forces* notes that:

Calmatives might be considered to deal with otherwise difficult situations in which neutralizing individuals could enable ultimate mission success;

The principle [*sic*] technical issue is the balance between effectiveness (i.e., the targets are truly “calmed”) and margins of safety (i.e., avoiding overexposure and resulting fatalities of neutral bystanders);

The treaty implications are significant.<sup>42</sup>

Research and development is not restricted to the United States. As events in Moscow illustrated, Russia clearly has a programme in this area and so may other countries. Authorities in the UK recently made it clear that no type of agent (RCA or incapacitant) would be used in military operations because of obligations under the CWC.<sup>43</sup> They are also hesitant in endorsing the use of incapacitating agents (as opposed to RCAs) for law enforcement purposes:

The decision to use any drug whether intended to induce a state of calm or complete unconsciousness requires knowledge of a subject’s medical history, particularly the use of any prescribed or non-prescribed medication and any relevant medical conditions. There would also be considerable responsibility in terms of immediate and post-incident aftercare.<sup>44</sup>

## IMPLICATIONS

If new biochemical agents are developed under the guise of non-lethal incapacitation it is likely that they will soon appear on the existing threat lists for chemical and biological weapons agents. There have already been warnings of this “double-edged sword”.<sup>45</sup> Such research is in danger of legitimizing offensive weapons development that is prohibited by the CWC and the BTWC.

## *Combined technologies*

A significant trend in non-lethal weapons development is the combination of one or more technologies into a single weapon. Examples of current systems include the paintball-type frangible projectiles (kinetic and chemical) and water cannons (kinetic and chemical or electrical). At the research and development stage wireless electrical weapons seek to combine electrical and directed energy technologies. Aqueous foams may combine a barrier function with the capability to incapacitate with the addition of chemical agents. A “Multi-Sensory Grenade” or “Clear-A-Space Device” employs light, sound and malodorant to overwhelm an individual or group, and “Flash-Bang” devices are also available that combine bright light and painful sound levels. Also proposed is a “multi-sensory incapacitation” approach to weapons development, targeting all five human senses (sight, sound, taste, smell, touch) as well as motor skill and cognition. As a result of the Ottawa Treaty (1997), which banned the use, development, production, stockpiling and transfer of anti-personnel landmines, there has been accelerated research into non-lethal alternatives. A range of mines are now being developed<sup>46</sup> including ones which fire out sticky entanglement nets, electrical stunning wires (Taser landmine), small rubber balls (Claymore type), chemical incapacitants, or a combination of these.

*A significant trend in non-lethal weapons development is the combination of one or more technologies into a single weapon.*

## *Delivery systems*

Accurate targeting and delivery of a non-lethal weapon defines their operational utility, and effort is going into the design of more effective delivery systems to enable increased stand-off distances and more discriminate delivery to the target. Advanced munitions, including shells or mortars for delivering chemical agents are being developed with the objective of dispersing the agent near the target whilst minimizing injury from the munition casing. Encapsulated projectiles, such as the paintball-type frangible capsules, are already deployed by law enforcement agencies for delivering OC/PAVA. The use of micro-encapsulation technology has been proposed for delivery of a variety of chemical substances since it has the advantage being able to achieve controlled or remote release of a given substance, or to compartmentalize multiple component systems. Delayed dispersal mechanisms enabling the release of material from the capsule over a period of time include: thermal release, mechanical rupture, water-activated release and photolytic release. Unmanned air vehicles are being increasingly deployed by the US military in their operations. Other unmanned systems include surface watercraft, underwater vehicles and ground vehicles. Whilst unmanned platforms have primarily been developed for use in sensing, surveillance or lethal weapons delivery, they are seen as having great potential for delivering non-lethal weapons at large stand-off distances.

## *Impact on health*

We have already noted some of the health effects of non-lethal weapons. It seems that often more urgent operational needs take precedence over a thorough evaluation of non-lethal weapon technologies. For example, in the case of Tasers, the National Research Council report on non-lethal weapons noted that “the actual mechanism of action is not well studied, but the commercial devices are effective”.<sup>47</sup> One study has reviewed the open literature on the effects of seven different non-lethal weapon technologies (acoustic weapons, entanglers, flash-bang non-lethal hand grenades, laser dazzlers, malodorants, non-penetrating projectiles, and oleoresin capsicum) with the objective of building a model to understand the effects of non-lethal weapons on humans. The ability to reach conclusions on the human effects of non-lethal weapons was hampered by the quality of the literature available for review:

empirically speaking, most of the studies were of a particularly non-scientific nature, including those sources which portray themselves as being objective and controlled. It is often difficult to extrapolate exactly what tests were used to assess the technology, what was measured, and—quantitatively speaking—what effects found.<sup>48</sup>

In 1999 the JNLWD established the Human Effects Process Action Team, which recommended the formation of a Human Effects Review Board (HERB) to review non-lethal weapon health effects and make recommendations, and a Human Effects Center of Excellence (HECOE) to carry out health-effects analysis. Both were set up in 2000.<sup>49</sup> However, the National Research Council study discovered that “HECOE is not funded to perform fundamental research on human effects. In fact, there is no place in the human effects characterization process, as established, where that research is supported.”<sup>50</sup>

There are other groups working on non-lethal weapon human effects. The Human Effects Advisory Panel is a group of experts formed in 1998 by the Institute for Non-Lethal Defense Technologies (INLDT) at Pennsylvania State University under contract with the JNLWD to provide advice on human effects.<sup>51</sup> INLDT is also closely involved with the JNLWD in weapons research and development. NATO

has a panel working in this area, the Human Factors and Medicine Panel, which is due to report at the end of 2004 on the human effects of non-lethal technologies.<sup>52</sup>

## Conclusion

We have noted that the military and police are interested in weapons that have a rheostatic capability, that is they can operate along a lethal to non-lethal continuum. A number of the non-lethal weapons described in this paper clearly have such a characteristic. At the same time existing weapons are being adapted to have a dual-use purpose. For example, the US Army has developed a "Lightweight Shotgun" that can either be attached underneath a standard automatic rifle or used as a stand-alone weapon. It can fire lethal or non-lethal rounds and has already been deployed in Afghanistan.<sup>53</sup> Rapid progress is being made in delivery systems that can dispense non-lethal weapons more accurately and discriminately from greater stand-off distances, and the development and use of unmanned vehicles and airburst munitions is important in this respect. Whilst the Taser electrical incapacitating weapon has been a "success" with thousands being sold worldwide to both civil and military users, analysts are concerned about the number of deaths associated with their use, and the lack of independent and scientific testing of health effects.<sup>54</sup> Although some of the other newer technologies are beginning to be field tested (such as the LRAD and ADS), it is the older and more established non-lethal weapons that are mostly in operational use. With regard to the military this is due to many factors including an uncertainty about the real utility of non-lethal weapons in combat. As a recent Council on Foreign Relations report notes:

The question remains: Where do the Department of Defense (DOD) and the armed forces stand on the road to acquiring and integrating these capabilities? We found little evidence that the value and transformational applications of nonlethal weapons across the spectrum of conflict are appreciated by the senior leadership of the Department of Defense. Despite successes on the small scale, NLW have not entered the mainstream of defense thinking and procurement.<sup>55</sup>

Another factor is the potential for quick development of countermeasures by opposition forces.

We would particularly want to highlight dangers posed by biochemical incapacitating weapons: both existing agents that do not fit the definition of "non-lethal", and novel agents that may be developed to incapacitate, damage the nervous system, alter moods, trigger psychological changes and even kill.<sup>56</sup> Classifying this new generation of weapons under the non-lethal umbrella must be resisted since it can give them "acceptability". They must be considered as weapons, which if developed and deployed, would contravene the international prohibitions of the CWC and the BTWC. The Council on Foreign Relations panel recognized the very significant dangers associated with such weapons development:

Nonmilitary research in biology and medicine will lead to understanding that can greatly facilitate the development, production, and use of lethal and largely nonlethal chemical and biological agents. But NLW-focused research will hasten the day that such materials are available not only to the United States but also to those who would use them against us.<sup>57</sup>

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