Centre for Conflict Resolution
Department of Peace Studies

Bradford Non-Lethal Weapons Research Project (BNLWRP)

Research Report No. 4

Neil Davison
Nick Lewer

December 2003

The Bradford Non-Lethal Weapons Research Project (BNLWRP)

The BNLWRP was established at the Centre for Conflict Resolution, Department of Peace Studies in 1995. The project's key objectives are to:

- Review and describe non-lethal weapons (NLWs) which are being developed and deployed.
- Identify and track defence and related research institutes involved in the development and manufacture of NLWs.
- Follow doctrine and policy debates related to the use of NLWs.
- Monitor the operational use of NLWs;
- Examine the impact of NLWs on international laws, arms treaties and conventions.
- Highlight the ethical questions that surround the research, development, deployment and use of such weapons.

Funding from the Joseph Rowntree Charitable Trust means that we will be able to develop our research and information activities. Over the next three years we will be focussing on:

- Regularly updating our website (http://www.brad.ac.uk/acad/nlw) to provide a systematic review of current NLW developments and critiques. We hope that the website will also provide access to our extensive annotated bibliography database, a facility, which we hope, will become an important research tool.
- Producing a quarterly report and analysis.
- Building on experience from our Edinburgh Seminar for Experts (2000), we plan to organise a second international seminar in 2005. This will bring together NLW manufacturers, politicians, NGOs, police and military forces, and the media.
- Publishing a book based on the 2005 seminar to provide an informed critical update on NLW developments.
- Creating and sustaining an UK/EU NGO network related to NLW development and concerns.

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Selected Publications by BNLWRP Staff

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Acronyms

ACPO	Association of Chief Police Officers
ADS	Active Denial System
APL	Advanced Polymer Laboratory, University of New Hampshire
ARDEC	Army Research and Development Engineering Command (U.S.)
ARL	Applied Research Laboratory, Pennsylvania State University
ATL	Advanced Tactical Laser
ATM	Anti-traction materials
BTWC	Biological and Toxin Weapons Convention
CCW	Convention on Conventional Weapons
COIL	Chemical Oxygen Iodine Laser
CS	Ortho-chlorobenzalmalononitrile / tear gas
CWC	Chemical Weapons Convention
DARPA	Defence Advanced Research Projects Agency (U.S. DOD)
DE	Directed Energy
DF	Deuterium Fluoride
DIP	Discriminating Irritant Projectile
DOD	Department of Defense (U.S.)
DOJ	Department of Justice (U.S.)
DSTL	Defence Science and Technology Laboratory (U.K.)
ECBC	Edgewood Chemical and Biological Center (U.S. Army)
EMP	Electromagnetic Pulse
FAS	Federation of American Scientists
FOI	Freedom of Information
GVS	Ground Vehicle Stopper
HALT	Hinder Adversaries with Less-than-lethal Technology
HEAP	Human Effects Advisory Panel
HECOE	Human Effects Center of Excellence
HEL	High-energy lasers
HEPAT	Human Effects Process Action Team
HERB	Human Effects Review Board
HF	Hydrogen Fluoride
HIDA	High Intensity Directed Acoustic
HPM	High Power Microwave
ILEF	International Law Enforcement Forum
INLDT	Institute for Non-Lethal Defense Technologies
IWC	Inhumane Weapons Convention
JNLWD	Joint Non-Lethal Weapons Directorate (U.S.)
KE	Kinetic Energy
LEWK	Loitering Electronic Warfare Killer
LRAD	Long Range Acoustic Device
MAV	Micro Air Vehicle
MCCM	Modular Crowd Control Munition
MCWL	Marine Corps Warfighting Lab (U.S. Marine Corps)
MDS	Mobility Denial System
MEU	Marine Expeditionary Units (U.S. Marine Corps)
NAS	National Academy of Sciences
NATO	North Atlantic Treaty Organisation
NATO HFM	NATO Human Factors and Medicine Panel

NEER	Nonlethal Environment Evaluation and Remediation Center, Kansas State University
NIHRC	Northern Ireland Human Rights Commission
NIJ	National Institute of Justice (U.S.)
NLW	Non-Lethal Weapon
NSWCDD	Naval Surface Warfare Center Dahlgren Division (U.S. Navy)
NTAR	Non-lethal Technology and Academic Research symposium
OC	Oleoresin Capsicum
OICW	Objective Individual Combat Weapon
OLDS	Overhead Liquid Dispersal System
PAVA	Synthetic Oleoresin Capsicum (OC)
PEP	Pulsed Energy Projectile
PSDB	Police Scientific and Development Branch (U.K.)
PVAB	Portable Vehicle Arresting Barrier
RAP	Ring Airfoil Projectile
RCA	Riot Control Agent
RF	Radio Frequency
RGES	Running Gear Entanglement System
SEAD	Suppression of Air Defences
SSRI	Serotonin selective reuptake inhibitor
SwRI	Southwest Research Institute
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle
UPP	Unmanned Powered Parafoil
USV	Unmanned Surface Watercraft
UUV	Unmanned Underwater Vehicle
VMADS	Vehicle Mounted Active Denial System
VTOL	Vertical Take-Off and Landing

1. INTRODUCTION

Non-lethal weapons (NLWs) are explicitly designed and primarily employed to incapacitate personnel or material whilst minimising collateral damage to property and the environment. Existing NLWs include rubber and plastic bullets, entangling nets, chemical sprays such as OC and CS gas, and electrical stunning devices such as the 'Taser' gun. New NLWs are on the way, which will include acoustic and microwave weapons, non-lethal landmines, malodorants, and sophisticated weapons developed through rapid advances in neuroscience and the genomics revolution. Most 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 NLWs, 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'. There is a continuing need for sustained and informed commentary to such developments which highlights the impact and threats that these technologies pose to civil liberties and human rights.

Because the last BNLWP Report was produced in August 2001, this edition is somewhat longer than usual so that key developments since then can be highlighted and summarised. Future BNLWRP reports will be published three times a year, and we welcome material to be considered for inclusion.

2. TECHNOLOGIES

This section of the report charts recent developments in non-lethal weapons (NLW) technology with a focus on those technologies that are moving closer to deployment by the military and law enforcement agencies. The areas covered are necessarily focused on the United States, partly due to the greater availability of information compared to other countries such as the U.K., but also because the U.S. is leading much of the research into NLWs. The desire for more accurate and discriminate weapons systems that combine the ability to apply force from increased 'stand-off' distances are important drivers for NLW development. As a result there is great interest in delivery systems that may help achieve these goals. In the military at least, technologies such as directed energy (DE) that could potentially offer 'tunable' capabilities (from non-lethal to lethal) are proving attractive. There is concern amongst many experts and observers over renewed U.S. military interest in incapacitating chemicals, which stands to undermine the Chemical Weapons Convention (CWC).

It is important to note that much information with regard to NLW research and development is classified and so it is not possible to determine the full scope of current research. The U.S. National Academy of Sciences Naval Studies Board published *"An Assessment of Non-Lethal Weapons Science and Technology"*[1] in early 2003, which gave an overview of the work of the U.S. military in this area. However, much research was discussed only briefly and the report lacked detail on the specifics of current research and development (R&D). Worryingly, a large number of reports on NLW development that were collected by the panel and due to become public records were held back from release by the National Academy of Sciences (NAS).[2]

2.1 ELECTRICAL

Electrical weapons, which include stun guns, stun batons, electrified shields, electrified nets, electrified water cannon, 'sticky shockers', stun belts, and Taser guns, mines and grenades have been described in detail elsewhere [3] and readers are directed to these sources. Amnesty International have identified manufacturers of electro-shock weapons in 12 countries [4] and their list indicates the largest group of manufacturers being located in Taiwan, China, South Korea, and the USA where the well-known Taser is produced. A report by the Omega Foundation for the Northern Ireland Human Rights Commission highlighted several problems related to the use of Tasers. [5] These included their potential use for torture and other human rights violations [6], that some people are more vulnerable to serious injury or death, that adequate medical research related to the safety of the more powerful Tasers has not been carried out, and that a Taser can ignite flammable materials (especially when vapours exist).

For the period 1990-2003 Amnesty documented electro-shock torture in 87 countries, and the report re-stated Amnesty's commitment to campaigning:

> ……for governments to recognise their responsibilities under international conventions prohibiting torture, and adopt measures to halt the production of and trade in electro-shock stun weapons until a rigorous and independent investigation has been conducted into their effects. [7]

Electrical weapons under development include: 'stand-off electrical incapacitation' - for example Meisterhans[8] has described the early development of a gas-disperse

(plasma) channel along which an electrical pulse can be sent; Taser type landmines which fire darts on wires[9]; and pulsed current devices designed to inject the electrical discharge from a capacitor into the electrical system of a moving vehicle's engine. The latter can be used, for example, in stopping vehicles during a high-speed pursuit or for protecting installations. [10]

This next section on electrical weapons will focus on the planned introduction of the Taser into UK Police Forces.

Electrical Weapons and the UK Police Forces

The Police Complaints Authority (PCA), after reviewing 24 firearms incidents referred to the PCA between January 1998 and November 2001, made a number of recommendations including:

> That there is an urgent requirement for the development of a coherent strategy for the use of 'less lethal' options including clearer evidence-based guidance on the use of general purpose attack dogs, the circumstances and training needed for the use of negotiators and the role of unarmed officers. In addition, urgent answers are required concerning the effectiveness and applicability of alternative weapons systems such as baton guns, water cannons and electrical or mechanical incapacitation devices.[11]

The PCA Report suggested that the use of a Taser may have been possible in 14 of the 24 incidents, but noted several concerns associated with 'less lethal' options including: the human effects of the weapon, that the introduction of such options would generally lower the threshold of when weapons are used, that adequate training is available, and their reliability and effectiveness. The report concluded that the development of less lethal options:

> ….must be addressed with utmost urgency to ensure that police response is consistent with the requirements of human rights legislation

At a meeting of the Co-ordination and Policing Committee of the Metropolitan Police Authority support was confirmed for the introduction of the M26 Advanced Taser for use as a less lethal option for the Metropolitan Police Service (MPS) as part of an Association of Chief Police Officers' (ACPO) 12 months operational trial which began 21 April 2003. However, the report notes that:

> ….less lethal options should not be a replacement to the police use of firearms. It remains the case that where a person is armed with a firearm, or is otherwise so dangerous as to put life in imminent danger, firearms will continue to be deployed, albeit now supported by less lethal options. [12]

and continued:

> In general, less lethal options are best utilised as a way of debilitating a suspect so that police can obtain a tactical advantage in appropriate circumstances.

The M26 Advanced Taser [13] (a single shot weapon) had been identified by the PDSB as the most appropriate weapon, and had been evaluated by the Defence Scientific Advisory Council (DSAC) sub-committee on the Medical Implications of Less Lethal Weapons (DOMILL). North Wales, Lincolnshire, Northamptonshire and Thames Valley police forces were also included in the trial. The MPA Report recommended that the Taser was to be used when:

> There is reason to suppose that its use is necessary and proportionate to reduce a serious risk of loss of life or serious injury, and other methods of policing to neutralise the threat have been tried and failed, or by the nature of the circumstances, are unlikely to succeed if tried.

For the purposes of the trial the Taser was only to be deployed when the use of firearms had been authorised. The first reported use of a Taser by police was by Metropolitan Police officers on 3rd August 2003 against an armed man. A prior attempt to incapacitate the gunman with a plastic baton round failed, so a Taser was used.[14] PricewaterhouseCoopers were appointed as independent evaluators, and an interim report was produced in November 2003.[15] Over the first six months of the trial the Taser had been deployed in 30 incidents (one of which involved a dog), and each of the 29 human situations resulted in an arrest. It had actually been discharged 6 times, and the Report noted that in three cases more than one discharge was required to incapacitate the target before an arrest could be made. The Taser also appeared to have a strong deterrent effect. A number of issues were raised including concerns from operational officers over the reliability of the Taser and the availability of realistic training ground scenarios. Some of the police involved in the trial thought that it should be broadened out to include violent incidents which did not call for firearms deployment. Following the use of the Taser by UK police on a woman who was threatening self-harm, the *Independent on Sunday* reported that police chiefs want to extend Taser trials so that they could be used in self-defence, arrest and restraint.[16]

Police in the UK and US are also testing the A3P3 (Aerosol Arresting Agent/Pulse Projected Plume) gun which combines several non-lethal technologies in one weapons system – electric shock, pepper spray and video surveillance technology.[17] The weapon uses sensors to judge the distance of an attacker before releasing the 'correct' amount of pepper spray. If an attacker is also electrically shocked at the same time, the resulting forced inhalation forces them to inhale more of the pepper spray. If the user comes under personal attack, a switch on the gun can transfer the electric charge to pads on the user's protective clothing. It is also fitted with tiny video cameras which can record events and also transmit 'real time' pictures back to the police control centre.[18]

Use in Crime

The Observer [19] reported that there is evidence of criminals increasingly arming themselves with stun guns (and CS sprays) in the UK. Data obtained from Customs and Excise shows that whilst the number conventional firearms seized has halved, the number of electrical stun guns has almost doubled. These weapons are available through purchase via the Internet, and *The Observer* investigation team managed to purchase a 200,000 volt stun gun and a 25ml CS spray. The report also notes that whilst it is illegal to possess such weapons (with a maximum sentence of 10 years and an unlimited fine), police and the courts seem to be taking a rather relaxed approach unless there is specific criminal intent.

2.2 DIRECTED ENERGY (DE)

'Active Denial' Technology

The Vehicle Mounted Active Denial System (VMADS)[20], which was first unveiled by the U.S. military in March 2001[21], employs a beam of millimetre wave electromagnetic energy to heat the skin of individuals in its path for use in 'area denial' or crowd control. The range of the VMADS is not in the public domain but the aim is to produce a system that can be effective beyond small arms range (around 750m).[22] Although it has been tested on animals and human volunteers, the full range of health effects from exposure to this weapon remain unclear. As a report published by National Academy of Sciences (NAS) in early 2003 stated:

> The VMADS effect – near instantaneous heating of an individual by the RF [Radio Frequency] energy – is well understood empirically, but much remains to be learned about the biological implications of such heating.[23]

The report also pointed out that:

> One area of concern with millimetre wave devices designed to induce biological effects is the potential for ocular damage such as corneal lesions, as well as the inadvertent exposure of targets at close range, which could lead to severe burns or other injuries.[24]

A paper presented at the 2nd European Symposium on Non-Lethal Weapons (2003) by scientists from the U.S. Air Force Research Laboratory reviewed the bioeffects research that has been conducted so far in relation to VMADS. They concluded that millimetre wave radiation acts in a dose-dependent manner and that the "…exposure duration is a critical factor."[25] The safety of this system is therefore dependent on the ability of subjects to move away from the beam before it causes damage to skin or eyes. Although, as the developers envisage, "…the target will have sufficient time to react to the painful response and withdraw from the situation…"[26], the question arises as to what happens if an individual is unable to move away from the beam for whatever reason. Despite the uncertainty concerning the health effects of this technology the U.S. Marines plan to field this system as early as 2005.[27]

High Power Microwave (HPM)

The U.S. military were reportedly to be considering the use of High-Power Microwave (HPM) weapons during the recent conflict in Iraq.[28] Such weapons deliver a burst of electromagnetic radiation designed to degrade or destroy the circuits of electronic equipment. There are two main types of HPM weapons: wide-band weapons which release a burst of radiation over a broad frequency range generated by a high explosive or an electromagnetic generator; and narrow-band weapons which are electrically driven and are directed at specific targets.[29] The former are often termed Electromagnetic Pulse (EMP) Weapons. According to the Directed Energy Directorate of the U.S. Air Force Research Laboratory based at Kirtland Air Force Base, New Mexico, where research into these weapons in conducted by U.S. Department of Defense (DOD), "A short burst of high-power microwave energy can be lethal to electronics while having no affect on humans operating the equipment."[30] However concern has been expressed over their potential secondary effects on civilian electronics such as hospital equipment and heart pacemakers.[31]

In their report, the committee investigating NLW's for the National Academy of Sciences (NAS) pointed out that although research has been carried out on HPM

weapons for over 25 years there has been 'little to no' scientific research into their mechanism of action. According to the report:

> A carefully structured scientific program is underway for some relevant targets. The program is classified and high risk, but if successful, it could substantially increase the efficiency and effectiveness of HPM weapons.[32]

HPM weapons have also been considered for engine stopping applications. One such system in the Ground Vehicle Stopper (GVS), which has undergone some initial testing although much more development work is needed.[33]

The United States is not alone in its research efforts. China, France, Russia and the U.K. are amongst the other countries developing HPM weapons.[34]

Lasers

The U.S. military has funded development of various 'dazzlers' or 'illuminators' such as the Saber 203[35], the Hinder Adversaries with Less-than-lethal Technology (HALT) system, and the Laser Dissuader all of which use red diode lasers[36] to temporarily blind or obscure vision. The manufacturers of the Laser Dissuader also produce the LazerShield, which incorporates a red diode laser on a plastic shield and is designed for use in law enforcement for incapacitating prisoners.

> Future plans for the HALT include the capability for dual red and blue wavelengths that flicker off and on to mitigate filtering by single-wavelength goggles.[37]

The U.S. Government also funded a project to produce the Laser Dazzler[38], which uses a random flashing green laser. There are concerns, however, over eye safety in relation to these devices.[39] A similar system under development by the U.S. Marine Corps Joint Non-Lethal Weapons Directorate (JNLWD)[40] is the Veiling Glare Laser, which uses violet light to cause the human eye to fluoresce so that the subject can see only glare.[41] Some scientists are uncertain as to both the effectiveness and safety of using this technique.[42] So far it has only been tested on cadaver lenses and its potential for eye damage remains unclear.[43]

High-energy lasers (HEL) are being investigated for non-lethal applications. The Advanced Tactical Laser (ATL) is a chemical laser[44] system being developed by Boeing for the U.S. military, which would be lethal if used against humans. Planned non-lethal uses include "…bursting automobile tires, rupturing fuel tanks, selectively cutting through electrical or communications lines, or setting fires."[45] However, the NAS report noted that chemical laser systems are very bulky and that:

> complex logistics and handling, high cost, and unconvincing demonstrations to date further contribute to the unattractiveness of chemical laser systems for non-lethal weapons applications.[46]

High-energy lasers are also being considered by the Joint Non-Lethal Weapons Directorate (JNLWD) for anti-personnel purposes. One such weapon being developed by JNLWD in collaboration with Mission Research Corporation is the Pulsed Energy Projectile (PEP), the effects of which were described in the NAS report:

> PEP would utilise a pulsed deuterium-fluoride (DF) laser designed to produce an ionised 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.[47]

Described by the former Director of the JNLWD being akin to a Star Trek 'phaser', the PEP will have a rheostatic capability that enables variable effects from non-lethal to lethal.[48] (This promise of adjustable or 'tuneable' power levels is seen as a major advantage of directed energy NLW's.[49]) As a non-lethal weapon it has been developed for use in crowd control by the military and law enforcement agencies. The system, which has a range of 2km is not person-portable but could be mounted on a vehicle or an aircraft. The PEP's development has been very secretive and there is little information available in the public domain. However, it is believed to be in the late stages of development.[50] The U.S. Marines view the PEP as a "promising technology"[51] but the NAS investigation into NLW technology exposed serious concerns. Experiments have shown that the pressure wave caused by the PEP penetrated further than expected into test materials and that the energy it produced at the surface of the target person could burn away clothing.[52] Overall recommendations made by the NAS committee to the JNLWD with regard to the Advanced Tactical Laser (ATL) and the Pulsed Energy Projectile (PEP) were not supportive of the technologies:

> The evidence presented to the committee supporting claims of the viability of both these concepts for non-lethal weapons use was not convincing. The directorate [JNLWD] is urged to reassess its investments in these programs.[53]

2.3 ACOUSTIC

The National Academy of Sciences (NAS) report in 2003 stated that:

> The concept of acoustic NLWs has focused on acoustic generators projecting sound downrange to affect crowds, to provide area denial, or to clear facilities. Generators that have been explored for producing these high intensities include sirens, whistles, pulse jets, vortex generators, explosives, and fuel-air devices.[54]

However, the report goes on to say that development of acoustic NLWs employing audible sound, infrasound or ultrasound in air has not been very successful.[55] Audible sound at high levels that causes pain in the ear can be effective in incapacitating someone but it is also likely to cause permanent damage to hearing. Another concern is that effects beyond those on the ear, caused by infrasound or ultrasound, have not been demonstrated effectively. (For a detailed analysis of acoustic weapons development see Jurgen Altmann's work in the field.[56]) The NAS report viewed underwater applications of acoustic NLWs to be more promising due to the increased coupling of acoustic energy and the U.S. Navy is investigating this application.[57] BAE Systems presented an idea for such a system to a NLW conference in 2002:

> A proposed deterrent system, based on existing underwater sonar transducers, uses an audio frequency alarm system to notify the swimmer/diver that they are in a restricted area. If the intruder is seen by the detection system to swim away, the alarm turns off. If they continue to approach, the system escalates to a more intense warning up through creating physiological effects using intense sound.[58]

Despite the apparent limitations of acoustic NLWs in causing incapacitation without irreversible adverse effects, some systems appear to be in the late stages of development. Some of these devices have arisen as secondary uses of a technology for 'directing sound'. Two companies have concurrently developed technologies that use ultrasonic frequencies to project sound in a narrow beam, so that only those individuals within the beam will be able to hear the audible sound created.[59] These devices are set to provide novel applications for the entertainment and advertising industries. However one of the companies, American Technology Corporation (ATC), has also developed the technology for NLW purposes. ATC's Military Operations Division has refined its directed sound technology to produce High Intensity Directed Acoustic (HIDA) devices. These devices will be marketed and sold by General Dynamics Armament and Technical Products (GDATP).[60] ATC is also working on research and development with the U.S. Army Research and Development Engineering Command (ARDEC) in Picatinny, New Jersey.[61]

A prototype device developed by ATC in 2001 is called the Directed Stick Radiator. This hand-held, battery powered directed acoustic device was considered for use in aircraft security after the attacks on 11 September 2001.[62] The stage of development of this device, which can emit a directed beam of audible sound at 140db is unclear but another device using HIDA technology, the Long Range Acoustic Device (LRAD)[63], has almost reached the marketplace. The LRAD is designed to deliver audible warning messages over long distances (500m - 1km) to individuals/vessels straying too close to 'security zones'. However, at closer distances it is considerably more incapacitating and, according to the General Dynamics fact sheet, LRAD can produce 120db of audio at 60m and peak levels of 130db at 4 metres.[64] (Hearing damage can occur at levels as low as 80db if exposure is over a long period. However, at levels of 120db and over there is potential for hearing loss even after very short exposures.[65]) In addition to ear pain, reportedly some HIDA devices can cause such side effects as loss of equilibrium, vomiting and migraines.[66] The U.S.

Navy are currently testing LRAD for use in ship protection with a view to installing the devices aboard ships in 2004 if testing is successful.[67] General Dynamics are marketing the device for use on "ground, air or sea platforms" and potential applications listed include "key asset protection" and "clearing areas / facilities".[68] Another device that makes use of directed acoustics is the Sonic Firehose, developed by Scientific Applications & Research Associates (SARA) in the U.S.A. It is designed to deter through targeting of intense sound at ranges in excess of 1km, and SARA have now produced person-portable prototypes.[69]

Vortex Generators

An acoustic technology receiving considerable R&D attention is the vortex generator. These generators can be used for the propagation of vortex rings[70], which are being investigated for their potential applications as non-lethal acoustic projectiles for crowd control. The principle idea behind this technology is to project a vortex of air at high speed towards a target to create an impact. At the 2nd European Symposium on Non-Lethal Weapons in 2003 several groups presented on this topic. These included papers by The Defence Science and Technology Laboratory (DSTL) of the U.K. Ministry of Defence on "Initial Simulations of a Single Shot Vortex Gun."[71], Bauman Moscow State Technical University reported research on "Application of Vortex Technologies for Crowd Control"[72], and the Fraunhofer Institute of Chemical Technology (ICT) presented a paper entitled "Impulse Transport by Propagating Vortex Rings – Simulation and Experiment."[73] Also, Scientific Applications & Research Associates (SARA) have been developing a NLW based on this technology for law enforcement purposes, called the Vortex Launcher. According to their web site, "The vortex feels like having a bucket of ice water thrown into your chest."[74]

2.4 CHEMICALS AND MATERIALS

Malodorants

The U.S. military has shown interest in malodorant compounds, (often termed 'stink bombs' or 'skunk shots'), for use as non-lethal weapons. The NAS assessment of NLW technology stated that malodorants "…have a strong potential for controlling crowds, clearing facilities, and area denial."[75] According to the study there has been recent work on characterising the effectiveness of these compounds, which could be used in combinations to "…address cross-cultural differences in effectiveness."[76] (Work on cultural susceptibilities was carried out by the Monell Chemical Senses Center in Philadelphia.[77]) A key recommendation in the NAS report is to identify opportunities for potential application of malodorants. However, concern was expressed over the persistence of these compounds in the environment and the need for further work on their health effects. The Nonlethal Environment Evaluation and Remediation Center (NEER) at Kansas State University is currently studying the potential environmental issues associated with two malodorant compounds developed by the U.S. military called 'Bathroom Malodor' and 'Who me?'[78] The centre is also conducting a toxicological assessment of malodorants. A presentation by NEER at the Non-lethal Technology and Academic Research (NTAR) symposium in late 2001 outlined some of the acute health effects that can be caused by odorous chemical substances under consideration for use as components of malodorant mixtures:[79]

Chemical	**Acute health effects**
dipropyleneglycol	Irritates eyes, skin, respiratory tract
skatole	
beta-thionaphthol	
mercaptoacetic acid	Abdominal cramps, tissue damage and irritation, coughing, choking, headache, dizziness, weakness, pulmonary edema, tightness in chest, air hunger, or cyanosis
t-butyl mercaptan	Eye and skin irritation, cough, headache, nausea, vomiting, dizziness
thiophenol	
ethyl sulfide	
n-caproic acid	Corrosive, causes burns, irritates eyes, skin, respiratory tract
n-methyl morpholine	
isovalericacid	

A study carried out by the Monell Chemical Senses Center for the JNLWD found that medium and high malodour concentrations elicit the following symptoms: reduction in respiratory volume, increase in respiratory rate, heightened electrodermal response, suppression of gastric signal amplitude and increase in frequency - consistent with tachygastria.[80]

According to the NAS report, the U.S. 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.[81]

Thus the U.S. classifies them as Riot Control Agents (RCAs). It is perhaps premature to make this classification since, as the NEER presentation in 2001 pointed out, there

is very little information available on the toxicity of the chemical components of malodorants.[82]

It appears that some malodorant systems are already commercially available. A report published by the Northern Ireland Human Rights Commission (NIHRC) notes that "…cadaver stench systems were being promoted at the Milipol Police and Internal Security Exhibition in Paris in November 2001."[83] Interestingly a biologist who used to work at the U.S. Naval Research Laboratory has developed a countermeasure to malodorants.[84] Two such products, 'Carry-On' and 'O-P-I (Odor Perception Inhibitor)', are available commercially.[85]

Anti-materiel chemicals

There are a number of chemical compounds are being considered for anti-materiel use by the U.S. Department of Defense, as outlined in the NAS report on non-lethal weapons:

> Classes of compounds having potential as antimateriel NLWs that have been examined include combustion modifiers, anti-additives, fuel contaminants, lubricant contaminants, viscosity-enhancing agents, depolymerization agents, and abrasives that might be used against engines and vehicles. Corrosive agents, depolymerization agents, and embrittlement agents could be used against a wider range of infrastructure.[86]

One of the main limiting factors with the development of these types of non-lethal weapons is the difficulty in delivering the agent to the target.

Anti-traction materials (ATMs)

Anti-traction NLWs are being developed for use against both vehicles and people. The Southwest Research Institute (SwRI) in Texas has developed a prototype Mobility Denial System (MDS) for the JNLWD.[87] This system sprays a highly slippery gel, formed from a mixture of polymers and water, onto surfaces to restrict the movement of people of vehicles. There are both man-portable and vehicle mounted versions of the system. The former consists of a backpack sprayer with a capacity of 5 gallons and a range of 20 feet enabling coverage of 2,000 square feet with the gel. The vehicle-mounted system dispenses 300 gallons of the gel with a range of 100 feet and covering 120,000 square feet.[88] The gel, which remains slippery for around 12 hours (and can be swept off the surface once it dries), is being developed for both military (e.g. bridge denial) and law enforcement (e.g. crowd control) applications and could be ready for deployment as early as 2004.[89] Drawbacks of the use of this type of system for civilian applications are the injuries that may result when people fall over or those caused when a vehicle goes of control in contact with the gel. Another concern with the use of ATMs is the potential for adverse environmental effects, and the Nonlethal Environment Evaluation and Remediation Center (NEER) at Kansas State University is conducting a project to evaluate environmental concerns related to ATMs.[90]

Researchers at the Emulsion Polymers Institute at Lehigh University in the U.S. have been working on the microencapsulation of anti-traction materials.[91] They have produced millimetre-sized beads that rupture under pressure of a person's foot or a vehicle tire. The use of these beads is designed to increase the longevity of the system to several days since the material inside dries at a much slower rate. The Emulsion Polymers Institute also produced particles in which the different components of the ATM are kept separated until the moment the bead is ruptured. Particles with a sticky outer surface for adhesion to walls or other surfaces have also

been developed. Research is being carried out into the development of beads that would release the ATM when triggered by specific environmental factors such as temperature or moisture.[92] This technology is also being applied to the delivery of other chemical agents such as incapacitants and malodorants. (see section on Delivery Systems)

Riot Control Agents (RCAs)

There have not been many significant developments as regards RCAs in recent years. PAVA, a synthetic version of oleoresin capsicum (OC) or 'pepper spray', has become more popular for use in law enforcement since it is more potent than the natural product. It is used widely by law enforcement organizations in North America and some European countries, including Police forces in the U.K. who now use PAVA sprays instead of CS. [93] Most attention in NLW development in the area of RCAs has focused on methods of delivery. For example, PepperBall Technologies, (formerly Jaycor Tactical Systems), produces PAVA filled projectiles for use with its PepperBall System. According to the company, the system, which made its first public appearance when deployed by police against demonstrators in Seattle in 1999, is currently used by "…more than 1,300 law enforcement, corrections, security and government agencies throughout the World."[94] The projectiles are fired at 300-380 feet per second using compressed air launchers with a range of 30 feet. The pistol-sized launcher (the SA10) has a capacity of 10 rounds, but a larger version of launcher (the SA200) can hold up to 180 rounds and this can be further expanded to hold 450 or 850 rounds. When the plastic projectile hits a person (or a hard surface) it breaks to release a small cloud of powdered PAVA. Recently PepperBall Technologies have made the technology available to the commercial market, and consumers in the U.S. can now by the pistol-sized version of the system with PAVA projectiles, re-branded as 'The Neutralizer', for personal use.[95]

Although the PepperBall systems fire PAVA projectiles they are not just characterised as chemical non-lethal weapons, since there is considerable kinetic impact when the rounds hit a person's body. The company call this combination of chemical and kinetic effects, 'Chemnetics'. There is a general trend in the NLW field to develop systems that combine different technologies for added effect (see Combined Technologies section). According to the company the kinetic impact of their projectiles is "…less than or equal to standard paintballs".[96] John Alexander, a retired Colonel in the U.S. Army who formerly worked on NLWs at Los Alamos National Laboratory reported his experiences testing the PepperBall system to a recent conference:

> The combined effects had me on my knees holding my chest and coughing in less than two seconds. Though asked questions about how I felt, there was great difficulty in speaking for the next couple of minutes. However, within five minutes most of the effects had dissipated. Vasel [Vice President of PepperBall Tactical Systems] had warned me that most people typically only welt or bruise. Depending on body fat content some people may *leak* a little. I was a leaker.[97]

A similar compressed air launcher system firing plastic rounds that break on impact is the FN 303 manufactured by FN Herstal. The launcher comes in two forms. One clips to the underside of an M16 machine gun, the other is a standalone launcher for use in law enforcement. Amongst the projectiles available are those filled with oleoresin capsicum (OC) or a OC/CS mixture.[98] FN Herstal also appears to have developed a projectile for this system with a malodorant payload.[99]

The Defence Science and Technology Laboratory (DSTL) are developing a similar chemical delivery system for RCAs called the Discriminating Irritant Projectile (DIP). Their research so far indicates a preference for a frangible projectile containing powdered CS mixed with silica powder.[100] As well as these recently developed breakable projectiles for delivering RCAs, there are a large variety of shells, grenades and spray devices for delivering these agents.[101]

There is concern over U.S. wishes to be able to use RCAs outside permitted law enforcement applications. In the run up to the recent war in Iraq, US Secretary of Defence Donald Rumsfeld testified to the US Congress House Armed Services Committee. He described situations where the use of non-lethal riot control agents (RCAs) in warfare would be appropriate. He went on to admit that the US was attempting to "fashion rules of engagement" to enable their use in the event of a war with Iraq.[102] Subsequently President Bush authorised their use in Iraq if required in certain circumstances.[103] This is legal in US law under Executive Order 11850, which was signed by President Ford in 1975 and permits the use of RCA's under specific conditions such as "in riot control situations in areas under direct and distinct U.S. 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."[104] However, it is illegal under international law. Article I of the 1993 CWC clearly states "Each State Party undertakes not to use riot control agents as a method of warfare."[105] Thus far RCAs have not been used in the Iraq conflict but these intentions expressed by the U.S. Government are certainly a cause for concern in terms of ensuring compliance with the CWC.

Incapacitants / Disabling Chemicals

One class of NLW that was reviewed 'favourably' in the 2003 NAS were incapacitating chemicals or 'calmatives'. The report concluded that "calmatives have potential as NLWs in many types of missions where calming of individuals or crowds is needed."[106] The Applied Research Laboratory (ARL) at Pennsylvania State University, who have worked with the U.S. military and law enforcement agencies on NLWs since 1997, carried out a study to assess the potential of calmatives based on the available literature. The report, *'The Advantages and Limitations of Calmatives for Use as a Non-Lethal Technique'*,[107] was finished in October 2000 but it did not become publicly available until obtained by the Sunshine Project in July 2002 under a Freedom of Information (FOI) request.[108] The report points out that pharmaceutical agents with potential as calmatives include "…compounds known to depress or inhibit the function of the central nervous system"[109], and goes on to say that these include "…sedative-hypnotic agents, anesthetic agents, skeletal muscle relaxants, opioid analgesics, anxiolytics, antipsychotics, antidepressants and selected drugs of abuse."[110] Specifically the report identified the following classes of 'calmative' compounds as potential non-lethal chemical agents:[111]

Benzodiazepines

- Used clinically for anti-anxiety, sedation and general anaesthesia – such as diazepam (Valium).

$Alpha_2$-adrenoreceptor agonists

- Used clinically for sedation, anti-anxiety, and to enhance the effects of other anaesthetic agents – such as dexmedetomidine (Precedex). One effect of Precedex is to increase the individuals' susceptibility to electric shock. The

report points to the possibility of using this drug in association with electrical non-lethal weapons such as the Sticky Shocker.

Dopamine D3 receptor agonists

- Clinical applications include use as an anti-psychotic drug.

Serotonin selective reuptake inhibitors (SSRIs)

- SSRIs are anti-depressant drugs – such as fluoextine (Prozac) and sertraline (Zoloft).

Serotonin 5-HT_{1A} receptor agonists

- Used clinically for the treatment of anxiety – such as buspirone (Buspar)

Opioid receptor and mu agonists

- Used clinically for analgesia (pain relief) – such as morphine, and fentanyl. The report points to the possible uses for carfentanil as a non-lethal calmative. The drug has thus far only been approved for use on animals, for example "The drug has been used successfully to immobilize a variety of large exotic animals."[112] Interestingly the report discusses fentanyl, a derivative of which was used by the Russian authorities to break up the siege in a Moscow theatre in October 2002.[113] It notes that fentanyl "…has a high abuse potential and may be habit forming (and serious life-threatening respiratory depression could occur)."[114] The latter clinical effect was devastatingly illustrated during its use in Moscow where it was responsible for the death of at least 129 of the 800 hostages; the Guardian recently reported that the death toll might be even higher.[115]

Neurolept anesthetics

- Intravenous anaesthetic drugs

Corticotrophin-releasing factor receptor antagonists

- Animal models show that these drugs produce "…calming effects after seizures induced in animal models."[116]

Cholecystikinin B receptor antagonists

- Potential use to 'inhibit panic'.

The recommendations section of the report emphasises the potential benefits for the U.S. military of collaboration with the pharmaceutical and biotechnology industries in the development of incapacitating chemicals as weapons. Furthermore it suggests that there may prove to be an ideal calmative amongst the thousands of pharmaceutical compounds already discarded:

> Often an unwanted side effect, such as gastrointestinal distress, will terminate the development of a promising new pharmaceutical compound. However, in the variety of situations in which non-lethal techniques are used, there may be less need to be concerned with unattractive side-effects; indeed, perhaps a calmative may be designed that incorporates a less than desirable side-effect (e.g. headache, nausea) as part of the drug profile.[117]

A final recommendation made in the ARL report is that a similar study be conducted to assess the potential of two other major groups of pharmaceutical agents: drugs of abuse (including selected club drugs) and convulsants.[118]

The legality of the development of these 'non-lethal' chemical incapacitants is addressed in a later section (see International Law section). Quite apart from these

legal issues there are fundamental problems with using incapacitating chemicals for the purposes proposed (i.e. non-lethal or less-lethal incapacitation). The main issue is the difficulty in delivering the correct 'dose' to achieve incapacitation without rendering individuals unconscious or causing death. A paper by the Federation of American Scientists (FAS) Working Group on chemical and biological weapons notes that anaesthetics such as those proposed for use as NLWs are not fatal when employed clinically because the dose to the individual is precisely controlled.[119] The paper goes on to point out why these conditions would not be achieved during police or military use of these agents:

> First, it is difficult to deliver a chemical agent quickly and uniformly to a large area. Thus, concentration will not be uniform throughout the area. Where the concentration is higher, lethality will be greater; and where the concentration is lower, the agent will be less effective. The only practical way to maintain effectiveness in the face of uneven concentration is to use enough agent to guarantee that the minimal concentration in any area exceeds that needed to achieve effective incapacitation. However, this will mean that some areas will contain higher concentrations of the agent, enough to cause significant lethality.[120]

The FAS Working Group also emphasise that the requirement for immediate effect will require higher doses (causing more deaths) and that in enclosed spaces where the agent cannot disperse victims exposed will receive a higher cumulative dose over time (causing more deaths).

In response to the results of fentanyl (derivative) usage during the Moscow theatre siege, the FAS Working Group developed a mathematical model to assess potential lethality of such incapacitating chemical agents.[121] They conclude that the use of these chemicals as incapacitants can be expected to cause at least 10% fatalities and that they should be considered lethal weapons since, as they point out:

> This is comparable to the effects of traditional "lethal" technologies. For instance, in military combat, firearms typically cause about 35% deaths among total casualties, shells about 20%, and grenades about 10%.[122]

Interestingly the editorial of the September 2003 *CBW Conventions Bulletin* notes that some chemicals that have been considered for use as non-lethal weapons are in fact more toxic than 'traditional' lethal chemical weapons:

> Lofentanil, for example, which is a derivative of fentanyl, is far more toxic than nerve agent. It will cause anaesthesia at a dose of 0.025 micrograms per kilogram body weight, which is hundreds of times smaller than the estimated lethal dose of VX.[123]

The Moscow siege demonstrated the availability of chemical incapacitants for use in law enforcement. It is unclear whether these types of chemical agents can also be accessed for military operations. Two reports in 2003 quoted Rear Adm. Stephen Baker, the Navy's former Chief of Operational Testing and Evaluation, as saying that U.S. Special Forces had 'knock-out' gases available for use in Iraq.[124]

The U.S. military claims that it ceased its research programme on calmatives in the early 1990's due to the restrictions of the 1993 Chemical Weapons Convention (CWC).[125] However this does not prevent ongoing research through the Department of Justice (DOJ), under the guise of use for law enforcement purposes.[126] One potential application of these agents was suggested by the Director of the National Institute of Justice (NIJ) in a statement to the U.S. House of Representatives on aviation security in 2002:

> Anesthetics or calmative chemicals could, in principle, be developed into a system whereby they could be remotely released into the cabin in order to incapacitate all passengers, and the hijackers, until the plane can be landed safely. Chemical systems of this type have not been employed in the field, however, and remain under study or in development.[127]

The same suggestion was made by the Director of the JNLWD in a presentation to the Airline Pilots Association in October 2001[128]

The NAS report in 2003 indicated that calmatives are now being studied by the U.S. military's Edgewood Chemical and Biological Center (ECBC) after a "…lull in R&D for 10 years."[129] One project is a sponge projectile designed to deliver a 'dose' of a fentanyl derivative.[130] If indeed this is a *renaissance* of military research into chemical incapacitants then it is hard to see what has prompted it. The wording of the CWC has not changed.[131] It likely comes down to "legal interpretations" of the Convention described in the NAS report on NLWs:

> …indicating that it [the CWC] does not preclude such work or the employment of such agents in specified and increasingly important military situations, such as civilian crowd control in peacekeeping or humanitarian relief operations.[132]

2.5 KINETIC ENERGY (KE)

KE weapons have a long history of use by police and military forces and were amongst the first NLWs developed. Despite the long experience of operational use, these weapons have their limitations. As the NAS report points out, "the short range of many of these munitions, together with their deteriorating accuracy at range, limits their use to situations involving short standoff distances."[133] More concerning are safety considerations. The report recognises that "control of trauma level from blunt projectiles remains a serious problem."[134] In a section on health effects the panel reports: "It appears that the development of kinetic NLWs is well ahead of the research on human effects."[135]

Impact Projectiles

There are a large number of different impact projectiles available, which come in a variety of shapes and forms. Many of these are designed for use with a standard 12-guage shotgun, 37mm launcher, or 40mm launcher. However, there are other projectiles of non-standard size that are fired with specially designed launchers (such as the PepperBall System and FN303 mentioned above). A study carried out by the ARL at Pennsylvania State University tested 80 different projectiles and categorised them in seven broad classes: Airfoil; Baton – foam, plastic, rubber, styrofoam, wooden; Drag-stabilized; Encapsulated; Fin-stabilized; Pads – rectangle and round; Pellets – single, multiple large, and multiple small:[136]

Airfoil

The Ring Airfoil Projectile (RAP) was originally developed by the U.S. military in the 1970's and consists of a piece of rubber in the shape of an aircraft wing moulded into a ring-shape.[137] It is one of the few non-lethal projectiles that is said to be non-lethal at the muzzle (i.e. at point blank range) and it has a range of up to 50 metres.[138] The original RAP (which was never used) was fired from an M16 rifle but since the U.S. National Institute of Justice (NIJ) funded renewed research into the RAP in 1997 custom launchers have been produced. The NIJ programme resulted in a RAP fired from a hand-held single-shot launcher. The rubber projectile itself incorporates 18 cavities that can hold chemical agent.[139] Guilford Engineering demonstrated a prototype RAP that delivered a small cloud of oleoresin capsicum (OC) released from the cavities upon impact as well as the kinetic impact. [140] More recently, in March 2002, the U.S. Department of Justice accepted a proposal from Vanek Prototype Co. to develop a multi-shot launcher for the RAP and projectiles that can deliver various payloads including incapacitants, irritants, malodorants, and marking agents over 50 metres.[141]

Baton: Foam, Plastic, Rubber, Styrofoam, Wooden

There are two types of baton projectiles: single projectiles made out of plastic, rubber or Styrofoam which are fired directly at the target; and those that consist of several projectiles in one cartridge (foam, plastic, rubber or wood) which may be fired directly or 'skip' fired.[142] Skip firing is when the projectile is fired so that it bounces off the ground before it hits the individual(s).

In June 2001 the U.K. introduced a new plastic baton round (plastic bullet) made out of polyurethane polymer, the L21A1, which was designed to be less

dangerous than earlier rounds due to its increased accuracy. However a report published by the Northern Ireland Human Rights Commission (NIHRC) in March 2003 found that the new round hits harder, is 2.5 times more likely to penetrate the skin, and has a higher potential for ricochet than the old round.[143] Moreover it found that the new round is more likely to cause injury, with 10.3% of the new rounds having caused injury compared to 1.14% of the old L5A7 rounds.[144] A Steering Group led by the Northern Ireland Office in consultation with the Association of Chief Police Officers (ACPO) has been investigating alternatives to the baton round and thus far has published three reports. The latest report (December 2002) concluded "…there is no single, available, item of equipment that could at this stage replace the current baton round."[145] The Defence Science and Technology Laboratory (DSTL) is developing a less-dense, 'crushable' impact round called the Attenuating Energy Projectile (AEP) as a potential replacement for the L21A1.[146]

Drag-stabilized

These types of projectiles have a flexible tail for improved stability through the air. Commonly they consist of a fabric pouch containing lead shot tied off with the excess fabric forming the 'tail'. They are called 'bean-bag' or 'sock' rounds and are often fired from a 12-guage shotgun. Initial versions of bean-bag rounds were square or rectangular and their edges increased the danger of penetration the body upon impact. Sock rounds were developed with no edges so as to reduce this risk. These types of rounds are the most commonly used impact projectiles by law enforcement agencies in the U.S..[147]

Encapsulated

These types of rounds are one of the more recent innovations and carry a payload enclosed in a casing that breaks upon impact. This payload may be a chemical irritant, paint/dye, or other material, and the projectile may be designed only to deliver its contents or to combine this with a significant kinetic impact. The PepperBall and FN303 irritant encapsulated projectiles have already been discussed in the section on riot control agents (RCAs). Other types of payloads available for the PepperBall System include paint for marking individuals, inert liquid (e.g. water), and inert liquid with antifreeze for use in cold conditions.[148] The FN303 can also fire a plain impact, paint filled, or illuminating (fluorescent) round .[149] There are other systems that fire frangible encapsulated rounds including the French Flash-Ball system that is used by the French police force. It can be used to fire both soft rubber projectiles and breakable ones containing either dye or CS powder.[150]

Fin-stabilized

These rounds are normally made from plastic or rubber, are cylindrical in shape with a blunt nose, and incorporate fins made of the same material at the rear of the projectile to increase stability.[151]

Pads: Rectangle and Round

One of the oldest forms of impact projectile these consist of a pad of nylon (or similar material) with silica, lead or steel shot sewn inside. Some of these rounds have added dye or chemical irritant.[152]

Pellets: Single, Multiple large, and Multiple small

These rounds consist of one of more spherical projectiles commonly made from PVC or rubber and fired using a shotgun or launcher.[153] Alternative non-lethal land mines also commonly employ multiple projectiles. One example is the Modular Crowd Control Munition (MCCM) developed by the U.S. military, which fires 600 PVC balls at a 45^0 angle with a range of 5-15 metres.[154] Other weapons developed by the U.S. military are mentioned in the NAS report:

> Rubber projectiles can be fired from standard-issue 12-gauge shotguns, either singly or in clusters of 12 balls, with a range of up to about 30 meters (m). The 40-millimeter (mm) Mk19 grenade developed for shooting from M203 and M79 weapons dispenses rubber balls for dispersing large crowds and achieving site security.[155]

At the 2003 Jane's Less-Lethal Weapons conference one speaker emphasised the importance of shot placement in relation to the use of impact projectiles.[156] Many of these types of NLWs can cause serious injury or death if they hit a sensitive part of the body. To avoid unintended shots the speaker recommended the use of single shot rounds since you cannot determine the direction of multiple rounds.[157] However, using single projectiles may not solve the problem of unintended hits due to limitations in accuracy. Scientists at the Applied Research Laboratory studying 80 different impact munitions were "…struck by the general inaccuracy of these munitions."[158] A similar study conducted by the U.K. Police Scientific and Development Branch (PSDB) evaluated 36 different impact projectiles and only 2 of those were considered sufficiently accurate to be taken forward for further evaluation.[159]

Water Cannon

Water cannons are now available in both vehicle mounted and portable forms and many incorporate reservoirs for adding chemical irritants or dyes to the stream. A report published this year by the Northern Ireland Human Rights Commission (NIHRC) noted some of the recent developments in this field:

> …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.[160]

Jacyor Inc. has developed an electrified water cannon with a range of up to 20 feet. The company proposes that it be used as an alternative to the Taser in targeting individuals or for crowd and riot control where "water can be sprayed on the crowd, delivering debilitating but not lethal shocks."[161]

2.6 BARRIERS AND ENTANGLEMENTS

Ground Vehicles

A number of new non-lethal barrier systems have been developed for stopping vehicles. The Portable Vehicle Arresting Barrier (PVAB) can stop a 7,500 lb vehicle travelling at 45 mph. Whilst it can be activated in 2 seconds, the set-up of the system takes at least an hour.[162] Developed by General Dynamics, the systems are now being delivered to the U.S. Army for use in the field.[163]

Another vehicle stopping barrier for use in law enforcement has been developed by the U.K. company QinetiQ. The X-Net is a man portable net that incorporates hollow spikes to both puncture the tyres and wrap around the wheels causing the vehicle to stop.[164]

Surface-Water Vehicles

The U.S. Navy and Coast Guard have shown interest in a barrier device for stopping propeller driven boats. The Running Gear Entanglement System (RGES) is essentially a net that becomes entangled in the propeller thus stopping the boat. Delivering the net to the target is the major obstacle however and the Navy is investigating compressed air launching systems.[165]

Individuals

Several years ago a U.S. company, Foster-Miller developed a net designed to capture an individual. The WebShot is a 10ft wide Kevlar net fired from a launcher with a range of 30 feet.[166] More recently the Japanese Police were reportedly testing a similar device in the run up to the 2002 World Cup.[167]

There is ongoing research into new barrier systems. Scientists at the Fraunhofer Institute of Chemical Technology (ICT) are working on novel barrier systems based on the principals of gas-generated airbags.[168] A research collaboration between the University of New Hampshire and the U.S. Army Natick Research, Development and Engineering Center is looking into the use of spider silk as a non-lethal 'entanglement' material for disabling people. They have developed a method for producing recombinant spider silk protein using *E. coli* and are trying to develop methods to produce large quantities of these fibres.[169]

Building Access

For a number of years researchers have been developing rigid foam for use as a non-lethal barrier to block access. Research is ongoing in the Advanced Polymer Laboratory & Chemistry Department at the University of New Hampshire. This JNLWD funded project is looking at rigid polyurethane foams with the aim of producing faster acting, more stable foams.[170] These types of foams are not considered safe for use against people due to the danger of blocking respiration.[171] Sandia National Laboratories in the U.S. developed sticky thermoplastic foam and associated dispensers some years ago. This type of foam is designed for use in area denial but not directly on people due to a similar danger of blocking respiration.[172]

2.7 BIOLOGICAL

The 1972 Biological and Toxin Weapons Convention (BTWC) prohibits the development, production, stockpiling or acquisition of biological agents and delivery systems for offensive purposes.[173] Most experts view this as a total ban on any offensive biological weapon. However, there are some interpretations of the Convention that consider biological non-lethal weapons, such as bacteria that degrade materiel, as legal.[174] It is not clear whether this loophole is being exploited to develop biological NLWs as such, but the U.S. military (including the JNLWD) has certainly shown interest this field.[175] Any development of anti-materiel weapons in the U.S. would contravene U.S. national legislation. The Biological Weapons Anti-Terrorism Act of 1989 includes in its definition of biological agents those that cause "deterioration of food, water, equipment, supplies, or *material of any kind*."[176] [emphasis added]

2.8 COMBINED TECHNOLOGIES

At the 2003 Jane's Less-Lethal Weapons Conference a former Director of the U.S. Joint Non-Lethal Weapons Directorate gave a presentation entitled 'Multi-Sensory Incapacitation'. He suggested an approach to non-lethal weapons development, termed 5sMC, which targets all five human senses (sight, sound, taste, smell, touch) as well as motor skill and cognition.[177]

A significant trend in non-lethal weapons development is the combination of one or more technologies into a single weapon. Examples already discussed in this report include the PepperBall System (kinetic and chemical), Ring Airfoil Projectile (kinetic and chemical), and water cannons (kinetic and chemical / electrical). As part of their work on the use of vortex rings as non lethal acoustic projectiles, The French-German Research Institute of Saint-Louis (ISL) have been investigating the delivery of various substances, such as chemical irritants, using the vortex ring as a carrier.[178] Aqueous foams used as non-lethal weapons can combine a barrier function with the capability to incapacitate with the addition of chemical agents.[179]

Another combined technology is the Multi-Sensory Grenade, being developed by Scientific Applications and Research Associates Inc. (SARA) for the JNLWD. It employs light, sound and malodorant to overwhelm an individual or group. It also has a modular design that may allow for incorporation of other technologies in the future.[180] The U.S. National Institute of Justice (NIJ) is funding an evaluation of this weapon for civilian use to control the movement of individuals or crowds.[181]

Flash-bang devices are available that combine bright light and painful sound levels to disorientate. The effects of a new generation flash-bang round developed for law enforcement purposes through funding from the National Institute of Justice (NIJ) were described by its developers in a recent article: "If you are the target, it would be pretty terrifying. You probably will think you are going to be incinerated."[182]

2.9 DELIVERY SYSTEMS

Currently one of the most intense areas of NLW development is work on delivery systems. Difficulty in successfully delivering a NLW is often a limiting factor in the use of new technology. Therefore considerable effort is going into the development of a variety of delivery systems that enable increased standoff distances and more specific or discriminate delivery to the target individual, group or object.

Unmanned Vehicles

These systems include unmanned aerial vehicles (UAVs), unmanned surface watercraft (USVs), unmanned underwater vehicles (UUVs), and unmanned ground vehicles (UGVs). The NAS report on NLWs recommended the acceleration of programmes exploring the use of these platforms for delivering NLWs and stated:

> Small UAVs, UUVs, and remote-controlled surface (water) vehicles offer attractive ways to deliver NLWs at large standoff distances with greater accuracy.[183]

Unmanned air vehicles (UAVs)

The NAS panel made several observations on the use of UAVs for delivering NLWs:

> UAV technology is being developed for many other applications, and several non-lethal payload deployments have been demonstrated from UAVs. Non-lethal technology applications will not drive UAV development; instead, non-lethal payloads will be integrated into UAV platforms that provide the required functionality of payload capacity, range, and delivery mode.[184]

Thus many of the different UAVs under development for other purposes (e.g. reconnaissance, sensing, lethal weapons delivery) could be adapted to deliver non-lethal weapons. For an idea of the large variety of UAVs in production and under development by both private companies and the military, the web site of the UAV Forum, http://www.uavforum.com/vehicles/vehicles.htm is informative. The site is run by SRA International, a private company that has collaborated with the U.S. Department of Defense on UAV development.

As mentioned in our Research Report Number 3[185], the Loitering Electronic Warfare Killer (LEWK)[186] is one UAV being considered for NLW applications. It is designed for suppression of air defences (SEAD) missions and combines radar-jamming equipment with the capability to deliver either lethal or non-lethal weapons. The LEWK is roughly the same size as a 1000 lb bomb and can be released from an aircraft in flight. It has inflatable wings that activate after launch, and can loiter in a target area for 8 hours. It has a parachute mechanism that enables its recovery.[187] Reportedly it is being tested this year (2003) with a launch from a Black Hawk helicopter[188], and operational demonstrations are scheduled for 2004. The LEWK is the main contender to replace the U.S. Marines Pioneer UAVs.[189]

The Dragon Drone / Exdrone UAV has already been developed by the U.S. military and may incorporate an NLW role. Originally designed as an expendable communications 'jammer', 500 were built and 45 were deployed during the first Gulf War in 1991. In 1997-8, 38 of these Exdrones were re-modelled and re-named by the U.S. Marines the 'Dragon Drone'. They have been deployed twice by U.S. Marine Expeditionary Units (MEUs).[190] Other sections of the U.S. military are carrying out research with Exdrones:

> Air Force Special Operations Command (Hurlburt Field, FL) is using 15 Exdrones as testbeds to explore potential UAV concepts and payloads for special operations forces. The Army Air Maneuver Battle Lab (Ft Rucker, AL) is also experimenting with Exdrones, having acquired 30 in 2001.[191]

The Exdrone is one of a number of UAVs produced by BAI Aerosystems. According to their web site the Exdrone "…offers a cost-effective means to perform reconnaissance and surveillance, and has also been used to deploy small sensors and *dispenser systems*."[192] [emphasis added] It is unclear what these dispensing systems can be used for but this type of system is particularly relevant to NLW applications such as delivery of riot control agents or incapacitating chemicals. General specifications for this UAV are as follows:

> The Exdrone is launched from a trailer-mounted pneumatic launcher, and may be either skid-landed on an improved surface, or recovered using an optional parachute system. Total all-up weight is approximately 100 pounds, with a cruise speed of 90 mph. Exdrone has a demonstrated effective range of 50 miles with over 2 hour flight endurance.[193]

Specifically the Dragon Drone can carry a 15 lb payload.[194] The Marine Corps Warfighting Lab (MCWL) is responsible for developing the Dragon Drone under its remit of "…developing new operational concepts, tactics, techniques, procedures, and technologies to prepare Marines for future combat."[195] The Marine Corps is also the lead agency of the U.S. DOD Joint Non-Lethal Weapons Directorate (JNLWD), and so this drone may be favoured for NLW use in the future. A short video of the Exdrone/Dragon Drone being tested can be accessed at: http://www.m2technologiesinc.com/compressed/RCSPDS(Glider).mov. It shows the UAV being tested with several different payloads.

The concept for delivering non-lethal payloads from UAVs is not a new one for the U.S. military. A representative from the U.S. Naval Surface Warfare Center Dahlgren Division (NSWCDD) presented a paper entitled *'Unmanned Aerial Vehicle (UAV) Non-Lethal (NL) Payload Delivery System'* at the Non-Lethal Defense III conference in 1998. He reported that a prototype dispenser for RCA munitions had been mounted on the Exdrone and Hunter UAVs for use in crowd control and that the system could be used with any UAV with a 40 lb or more payload capability.[196] The capability to disperse liquid or aerosol payloads has also been available for some time. The Southwest Research Institute described the following in their annual report for the year 2000:

> SwRI engineers developed a computer-controlled unmanned powered Para foil (UPP) equipped with a payload that dispenses liquid spray while in flight. Developed for the Marine Corps Non-Lethal Directorate, the system is intended to provide non-lethal crowd control options for the U.S. military. The UPP was fitted with a pan-tilt camera to continually locate the impact point of the liquid spray. Using computer-assisted flight modes and the camera image, a remote operator can direct the UPP over a target at low altitude and release the spray.[197]

The UPP was mentioned in the NAS report as a "…remote-controlled aerial spray dispenser for NLWs."[198] The JNLWD has also carried out a study of another UAV-type delivery system for NLWs, the Loitering Submunition.[199]

The following scenario is presented in the NAS report for the potential use of UAVs:

> In a difficult crowd control situation, the decision is made to use calmatives, which must be applied within a specific range of concentrations. To ensure proper dosing, a small UAV is launched, dropping remote sensors containing chemical "laboratory" electronic chips that give chemical analysis feedback to adjust the release level of calmative agents in the target area.[200]

Although the UAVs in this scenario are used to deliver sensors it is clear from the research already that the intention of the JNLWD is to also have the capability to deliver the incapacitating chemicals buy UAV.

The U.S. Defence Advanced Research Projects Agency (DARPA) is developing a number of UAVs. The A-160 Hummingbird is essentially an unmanned helicopter with the capability for vertical take-off and landing (VTOL). The Hummingbird is designed to have a very long range and flight endurance and DARPA's goal is to develop a system weighing 4,000 lb, with a range of 2,500 nautical miles that can stay in the air for 40 hours at a time and carry a 300 lb payload. Potential missions identified include non-lethal weapons delivery.[201] The flight test programme for this UAV began in early 2002.[202] So far the U.S. Army and U.S. Special operations are most interested in the Hummingbird and the Army are considering buying the first two Hummingbird UAV's in 2006.[203] DARPA's Tactical Technology Office is working on several other UAV designs including Micro Air Vehicles (MAVs)[204], which are likely to be used for surveillance or sensing purposes although they may have applications for NLW delivery. The NAS report suggested that they might provide a solution for the delivery of antimateriel agents to the air intake of an engine, for example.[205]

The UAV Roadmap, published in December 2002 showed that there is great deal of investment planned for the UAV field in the U.S.:

> Between 1990 and 1999, the Department of Defense invested over $3 billion in UAV development, procurement, and operations. The current FY03-09 Presidential Budget for UAV programs of $16.2 billion will help multiply that amount by nearly six times in the current decade.[206]

Although UAV development is being pursued for many different purposes this technology will remain relevant and applicable to NLW delivery. It is important to note that the U.S. in not alone in its interest in UAVs. As of December 2002 there were 32 countries developing or manufacturing over 250 models of UAV.[207]

Other unmanned vehicles

Other types of unmanned vehicles are being considered for use by the U.S. military. The NAS report noted:

> Smart buoys, teleoperated or autonomous robotic jet skis ("Roboski"), or modified launches could also be envisioned as potential non-lethal delivery platforms in the Navy context.[208]

The Robotic Jet Ski (Roboski) has already been demonstrated as a potential weapons platform (lethal and non-lethal) and tested as a delivery system for the Running Gear Entanglement System (RGES). The NAS panel suggested that:

> A Roboski platform might also be used to deploy a drag chute over a vessel; warning devices such as sirens, flashing blue lights, strobe lights; flash-bang munitions; pepper spray; blunt trauma munitions; or a water cannon.[209]

On land, unmanned ground vehicles (UGVs) may be used to deliver NLWs. The Gladiator Tactical Unmanned Ground Vehicle[210] is being developed as both a lethal and non-lethal weapons platform.[211] The Marines tested the potential of the Gladiator for use in crowd control earlier this year when it demonstrated the ability to fire a variety of non-lethal munitions including paintball-type encapsulated rounds.[212]

Non-Lethal Munitions

Aside from development of non-lethal kinetic munitions, much work in the U.S. military is going into design of advanced munitions for delivering chemical agents for non-lethal purposes. Many of these are designed to disperse the agent near an individual or group without the risk of significant kinetic impact from the munition. Thus these munitions can be fired directly unlike traditional RCA grenades and shells. Like many chemical delivery technologies these new systems may be applicable to both RCA and incapacitant (calmative) delivery. One such system under development is the Objective Individual Combat Weapon (OICW) Non-Lethal Munition, which is a small (20 mm) airburst munition for more precise delivery of RCAs over 5-1000m. It has been tested at ranges up to 250m with a CS payload.[213]

A larger system is the 81mm Non-lethal Mortar Cartridge under development by the U.S. Army to enable NLW delivery at large stand-off distances. The development aim is a mortar that can deliver a solid, liquid, aerosol or powder payload from 200m up to 2.5 km from the target.[214] One protype incorporates a parachute system that activates above the target just before the payload is released so that the shell does not cause injury through kinetic impact and it has already been through a 'proof-of-principle' test at a range of 1.5 km.[215] The Sunshine Project has made available a number of documents that chart the development of this 81mm mortar over several years. It has been developed primarily for long-range delivery of chemical agents ostensibly for crowd control purposes.[216] However, some observers question the need for a 2.5 km range in crowd control operations.[217] Tests have been conducted (November 2002 and February 2003) on both frangible and non-frangible versions of the mortar for liquid dispersal, the aim being to cover an area of 25 m^2. In addition, Edgewood Chemical and Biological Center (ECBC) have begun a study of potential malodorant payloads for the mortar munition.[218] Another programme that has fed into the general development of long-range liquid agent delivery systems is the Overhead Liquid Dispersal System (OLDS), which has successfully demonstrated the ability to disperse liquids over large areas (13m diameter circles) at a range of up to 175m.[219]

Earlier this year the Sunshine Project drew attention to a U.S. Army patent for a 'Rifle-launched non-lethal cargo dispenser' for delivering a variety of non-lethal payloads including obscurants, aerosols, flash-bang grenades, sting balls, or sensors.[220] The patent claims that the device is suitable for delivering a variety of aerosols including "…smoke, *crowd control agents, biological agents, chemical agents*, obscurants, marking agents, dyes and inks, chaffs and flakes."[221] [emphasis added] The actual development of this delivery system for biological agent delivery would violate the Biological Weapons Convention (BWC).[222]

Encapsulation and Microencapsulation

Encapsulation and microencapsulation technologies are increasingly being seen as methods for more accurately delivering chemical agents, such as RCAs, incapacitants and malodorants. Encapsulated projectiles, such as those for the PepperBall and FN303, are already in use by law enforcement agencies for delivering OC/PAVA, and malodorant rounds are forthcoming (see RCAs section). Such paintball-type encapsulation technologies may also be applicable to delivery of incapacitating chemicals and at least two university departments have carried out research on encapsulation and microencapsulation for the U.S. JNLWD. As discussed earlier, Lehigh University are looking at microencapsulation for anti-traction materials (see Chemicals and Materials section) and the Advanced Polymer Laboratory (APL) at the University of New Hampshire has been carrying out research into the use of

microencapsulation for a variety of chemicals. In a presentation to the Non-Lethal Technology and Academic Research Symposium in 2000 APL proposed various reasons for encapsulating NLWs:[223]

- To achieve controlled/remote-release.
- Make active materials easier/safer to handle.
- Compartimentalize multiple component systems.
- Protect sensitive materials from their environment.
- To turn liquids into powders/solids.

Candidate substances for encapsulation include RCA's, incapacitants, malodorants, dyes, and anti-materiel agents such as combustion modifiers. They suggest that encapsulated NLWs could be delivered from a variety of platforms such as shotguns, launchers, airburst munitions, mortars, and UAVs. The capsules themselves may vary in size from 1 micron to 1mm or more depending on the application. Different sized capsules are produced with various physical and chemical methods. For example, the smallest capsules are produced using spray-drying techniques. The researchers have also been looking at potential secondary release mechanisms (other than initial impact after dispersal) that could be used to control the release of the materiel inside the capsule such as:[224]

- Mechanical rupture (weight of a human)
- Thermal release (activation temperature)
- Shell dissolution (presence of water)
- Photolytic release (exposition to (sun)light)
- Osmotic and pH-dependent release
- Enzymatic release
- Electric current

The Current Projects page of the APL web site states that they have already demonstrated thermal, mechanical and hydrolitic release mechanisms in their encapsulation work for the U.S. JNLWD and that:

> …several non-lethal crowd dispersion weapons have been developed. These include mace, dye or malodorants encapsulated in polymers. Others include various liquids developed for crowd dispersal.[225]

The APL is carrying out other work for the JNLWD to facilitate the delivery of these types of agents. They have produced shells formed from carbon fibre and epoxy composites in support of the non-lethal mortar development programme.[226]

Microencapsulation is clearly seen as a potential solution to the problem of being able to target and control delivery of chemical agents as non-lethal weapons. The NAS panel recommended that the microencapsulation and related techniques should be explored since that may enable the creation of "…new, more deliverable forms of chemical NLWs."[227]

3. HUMAN EFFECTS

The human effects of some NLWs have been discussed in earlier sections of this report relating to specific technologies. It is widely recognised that there has been relatively little attention given to study in this area.[228] Often safety evaluations of weapons are produced by the manufacturers themselves and independent scientific research and evaluation is scarce. The Taser is a case in point: although much is made of the number of people who have received a Taser shot and lived to fight another day, there has been relatively little scientific assessment of the health effects.[229] In the U.K., the Defence Science and Technology Laboratory (DSTL) carried out an assessment of the medical effects of the M26 Taser before the current 12-month trial of the technology began with the UK police. Their evaluation was primarily a literature review of the information available publicly and from the manufacturer. Although they concluded that, "from the available evidence on the use of the device, the risk of life-threatening or serious injuries from the M26 Advanced Taser appears to be very low"[230], they noted the limitations of the data this decision was based on:

> 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.[231]

More urgent operational needs seem to take precedence over thorough evaluation of NLW technologies. As discussed earlier, the NAS panel reported that the studies of the health effects of KE projectiles lag well behind work on their development. And these are the oldest of the NLW technologies. The short discussion of the health effects of electrical weapons (such as the Taser) in the NAS report reinforces this view. They concede that "The actual mechanism of action is not well studied, but the commercial devices are effective."[232]

A paper presented to the 2nd European Symposium on Non-Lethal Weapons (May 2003) by TNO Human Factors addressed the *Effects of Non-Lethal Weapons on Humans.*[233] Their study reviewed the open literature on the effects of seven different NLW technologies: Acoustic weapons, entanglers, Flash-bang non-lethal hand grenades, laser dazzlers, malodorants, non-penetrating projectiles, and oleoresin capsicum. The purpose of the work was to contribute to a model for understanding the effects of NLWs on humans, and the research categorised potential effects into three groups: physical effects, psychological effects, and behavioural effects. The ability to reach conclusions on the human effects of these NLWs 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.

The U.S. military's JNLWD has established a number of groups to address the issue of human effects of NLWs. The Human Effects Process Action Team (HEPAT), composed of U.S. DOD experts, was set up in 1999. HEPAT's final recommendation was the formation of a Human Effects Review Board (HERB), to review NLW health effects and make recommendations, and a Human Effects Center of Excellence (HECOE) to carry out health effects analysis. HECOE was established in the summer of 2000 and HERB was set up in October 2000.[234]

However, as the NAS panel reported in 2003:

> 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.[235]

Overall the panel found that the JNLWD efforts to address human effects are 'insufficient' and that "without substantial change, the lack of effects characterization will be a "show-stopper" for deploying non-lethal weapons to the field."[236]

In the law enforcement field there is also recognition of the importance of characterising the human effects of NLWs. The main recommendations from the 2002 International Law Enforcement Forum (ILEF) included the development of standards for testing NLWs, and the conduct of independent assessments of the technologies. These recommendations relate not only to human effects but also to NLW effectiveness, and operational issues.[237] These sentiments were echoed by speakers at the 2003 Jane's Less-Lethal Weapons Conference in Glasgow.[238]

As regards assessment of NLW human effects there are some further research is in progress. The Human Effects Advisory Panel (HEAP) is a group of experts formed by the Institute for Non-Lethal Defense Technologies (INLDT) at Pennsylvania State University in 1998 under contract with the JNLWD to provide advice on human effects.[239] INLDT, as already discussed in this report, are also closely involved with the JNLWD in weapons research and development. NATO also has a panel working on NLW human effects. The Human Factors and Medicine (HFM) Panel 073, which is due to report this year on the "*Human Effects of Non-Lethal Technologies*".[240]

4. INTERNATIONAL LAW

Non-lethal weapons development impacts on several international treaties including the Biological and Toxin Weapons Convention (BWC), the Chemical Weapons Convention (CWC), the Convention on Conventional Weapons (CCW) (also known as the Inhumane Weapons Convention (IWC)), and the Ottawa Convention on Landmines. The use of NLWs in warfare is also governed by the *law of war* or international humanitarian law. For recent perspectives on the implications of NLW development for international humanitarian law the reader is directed to papers presented to the 2003 2nd European Symposium on Non-Lethal Weapons.[241]

Of the treaties mentioned above the CWC is perhaps under the greatest threat from NLW development. In the U.S., for example, there is continuing military interest in incapacitating chemicals and a desire be able to use RCAs in warfare, which would contravene the prohibitions of the Convention. Senior figures in the U.S. administration have made no secret of their contempt for the restrictions of the CWC. For an in-depth review of these issues the reader is directed to a number of recent sources on this topic.[242] As discussed earlier in this report, the prohibitions of the BWC are also being tested by legal interpretations that would deem anti-materiel biological weapons acceptable.

5. BOOKS

Book Review

Alexander, J. B. (2003) *Winning the War: Advanced Weapons, Strategies, and Concepts for the Post-9/11 World.* New York: St. Martin's Press.

In the follow up to his 1999 book *Future War*[243] John Alexander, a retired Colonel in the U.S. Army and member of the National Academy of Sciences panel that produced an extensive report on non-lethal weapons science and technology in 2003, expands his remit beyond NLW issues. He presents his view of the U.S. military's role in the current and future international security environment, and the techniques and weapons they may employ. Akin to an 'enhanced' U.S. National Security Strategy, *Winning the War* advocates an even more assertive approach than that set out in the actual National Security Council document released in September 2002[244]. As regards NLWs, Alexander emphasises the need for such weapons due to the increasing number of situations where U.S. forces face a mixture of combatants and non-combatants. Current operations in Iraq are a good example. It is strange then that we have not seen more reports of NLW use in Iraq given that U.S. Marines and other units are equipped with them and domestic law enforcement agencies in the U.S. have long deployed a variety of these systems for crowd control. Alexander makes it clear that NLWs are not meant to be a replacement for lethal force, (merely an addition to the tools available), but so far it seems that soldiers would prefer to rely on their M16 when faced with a hostile crowd. The role of NLWs in the military remains unclear, whilst new systems are readily deployed by police forces.

In the book, concerns over the misuse of certain NLW technologies are dismissed with his assertion, oft repeated, that it is not the technology that is inherently bad, rather it is the operator that determines whether the weapon is misused. This argument is the similar to that used by the National Rifle Association (NRA) in opposition to gun control in the U.S.: "Guns don't kill people, people kill people." Whilst it is unwise to dismiss the utility NLWs out of hand, it is also foolish to dismiss legitimate concerns over certain NLW technologies. An ongoing debate, whilst it may distract from the focus on operational requirements, is important.

Winning the War is divided into four main parts. The first addresses the "Tools of War" with a look at weapons systems both lethal and non-lethal. Alexander provides a useful discussion of NLWs already widely used such as the Taser, the PepperBall system and laser dazzlers. He also looks at technologies that are moving closer to deployment such as the Active Denial System (ADS), High Intensity Directed Acoustic (HIDA) devices, and the Running Gear Entanglement System (RGES). There is also discussion of directed energy (DE) systems such as the Advanced Tactical Laser (ATL) and the Pulsed Energy Projectile (PEP) as well as acoustic and HPM devices. The rest of this section is given to advances in sensor systems (e.g. satellites, and face recognition) and lethal technologies (e.g. thermobaric bombs). Another section relevant to NLWs covers advances in unmanned vehicles. Recognising that there is much literature elsewhere, Alexander does not address weapons of mass destruction (WMD) save a closing comment to the first section of his book:

> Should a major chemical, biological, or dirty nuclear attack be made against the United States, it is likely that public indignation and anger, so far relatively muted, would not only support massive nuclear retaliation; they would demand it. [p. 84]

But retaliation against who? In the new security environment that Alexander describes the perpetrators of such an attack may not be easily discernable, especially following a covert attack with biological weapons for example.

The second section of the book depicts six fictional scenarios designed to show the utility of new tools of war in future conflict. With regard to NLWs, the use of incapacitating chemicals features prominently. Alexander is a keen proponent of these chemicals and throughout the book he calls for the revision of current treaties (the CWC and the BWC) to allow their use. (For a discussion of these issues refer to the earlier sections of this Research Report as well as papers cited in reference No. 242)

Part three of the book shifts attention away from specific weapons systems and toward the 'War on Terror'. This section moves away from NLW issues but is worth commenting on. Alexander discusses the importance of cutting finance to terrorist organisations and he attacks the news media for their coverage of conflict and difficult issues such as NLWs. However, it is his outrageous two-step solution to the problem of suicide bombers that draws attention:

> First we need to kill as many terrorists as possible without allowing them to surrender. The next step is even harsher and is currently unacceptable. It will not be considered until sufficient pain has been inflicted on Americans that they are prepared to do whatever is necessary to exterminate the threat. [p. 200-1]

Worse follows, and he continues:

> The currently unthinkable action step is to put the families of terrorists at risk. When suicide bombers are identified all known family members should be targeted for assassination. However harsh, this is the only method that has a chance of stopping the attacks. [p. 201]

Alexander recognizes that most of us would find such a strategy both abhorrent and ridiculous. But he puts our dismissal down to political correctness. Amazingly his tirade does not stop there, he concludes this section of the book by revisiting the idea of nuclear retaliation:

> If the terrorists are not stopped before they reach our breaking point, it will become necessary for us to eliminate a country so that we regain respect.

In the final part of the book he offers his 'Plan B' for future warfare. He advocates the militarization of space and points to the utility of technologies such as weather modification and even remote viewing and psychokinesis. On a more encouraging note, perhaps the most positive suggestion in the book is his call for increased investment in alternative energy sources that may enable the U.S. to stem their reliance on oil.

Other recent books

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National Academy of Sciences (2003) *An Assessment of Non-lethal Weapons Science and Technology.* Washington D.C.: National Academies Press.

Lewer, N (Ed). (2002) *The Future of Non-Lethal Weapons. Technologies, Operations, Ethics and Law*. London: Frank Cass.

6. CONFERENCES

Forthcoming Conferences

International Law Enforcement Forum (ILEF)
February 2004
Royal Society of Arts, London, U.K.

Non-Lethal Defense VI
March 2004
For more information contact the National Defense Industrial Association (NDIA):
http://www.ndia.org/

3rd European Symposium on Non-Lethal Weapons
2004
Details to appear on the following web site:
http://www.non-lethal-weapons.com/

Recent Conference Proceedings and Programmes

The Non-lethal Technology and Academic Research Symposium V (NTAR V)
5-6 November 2003
http://www.ntar.sr.unh.edu/PublicSchedule.shtml

Jane's Less-Lethal Weapons 2003 Conference – "Critical Incident Intervention"
2-3 October 2003
http://www.janes.com/security/conference/llw2003/overview.shtml

2003 Mines, Demolitions, and Non-Lethal Weapons Conference & Exhibition
9-11 September 2003
http://www.ndia.org/Content/NavigationMenu/Meetings_and_Events/Past_Events/2003_Mines_and_Demolitions_3500.htm

2nd European Symposium on Non-Lethal Weapons
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