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# **The Contemporary Development of “Non-Lethal” Weapons.**

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### 1. Introduction

This is the third in a series of Occasional Papers published by the Bradford Non-Lethal Weapons Research Project. It addresses the contemporary development of anti-personnel “non-lethal”<sup>1</sup> weapons, covering the period from 2000 to 2006 inclusive<sup>2</sup> and focusing on the research and development programmes of the US Department of Defense and Department of Justice. Following Occasional Paper No. 1, *The Early History of “Non-Lethal” Weapons*,<sup>3</sup> and Occasional Paper No. 2, *The Development of “Non-Lethal” Weapons During the 1990’s*,<sup>4</sup> this paper completes our analysis of the overall development of “non-lethal” weapons from their inception up to the present day.

### 2. Police Developments

During 2000 the US National Institute of Justice had 17 ongoing projects on “non-lethal” weapons that had been funded during the mid to late 1990’s. With regard to anti-personnel systems the focus was on kinetic impact projectiles, irritant chemical agents (OC/‘pepper spray’), and the Capture Net or WebShot. As regards impact projectiles and OC, research was primarily directed at safety and effectiveness studies. Development of the Laser Dazzler weapon was ongoing as was investigation of a so called ‘active light barrier’. The latter involved the use of a bright light source shone onto scattered particles to provide a visual obstacle to a crowd.<sup>5</sup> Further assessment and development of the ring airfoil projectile (RAP) and the ‘Sticky Shocker’ electrical projectile was ongoing.<sup>6</sup>

Furthermore, in 2001, NIJ began an association with the Institute for Non-Lethal Defense Technologies (INLDT) at Pennsylvania State University (PSU), the group working closely with the Joint Non-Lethal Weapons Directorate (JNLWD). NIJ funded a three phase project as follows:

Phase One will establish test protocols for Attribute-Based Evaluations of Less-Than-Lethal (LTL) munitions; Phase Two will conduct an investigation of controlled exposure to caluminate-based oleoresin capsicum. Phase Three will provide an E-Forum to support an operational needs assessment for less-than-lethal technologies.<sup>7</sup>

Funding for Phase One contributed towards a joint study by the Applied Research Laboratory at Pennsylvania State University (PSU) and the Los Angeles Sheriff’s Department (LASD) testing the accuracy and impact force of a range of kinetic impact projectiles to augment the often scant and unverified information provided by manufacturers. In February 2001 they published a report of the tests conducted, entitled *Attribute-Based Evaluation (ABE) of Less-Than-Lethal, Extended Range, Impact Munitions*.<sup>8</sup> It is less clear what research has been carried out in relation to Phase Two on the combination of oleoresin capsicum (OC) and incapacitating chemicals. The most recent information on this project comes from a February 2003 presentation made by Joe Cecconi, the Senior Program Manager for the NIJ Less-Than-Lethal

Technology Program, which indicated that the project had been reviewed by a liability panel and that work was progressing at PSU.<sup>9</sup> The same group at PSU has also conducted work on incapacitating chemicals for the Joint Non-Lethal Weapons Directorate (JNLWD) (see section 4.3 Military Developments). Phase Three on the establishment of an E-Forum has been completed and it is hosted on the web site of the Institute of Non-Lethal Defense Technologies (INLDT).<sup>10</sup>

After the attacks in New York and Washington on September 11 2001, attention quickly turned the potential for using “non-lethal” weapons aboard aircraft. The National Institute of Justice annual report for 2002 noted:

Airline safety became an issue of paramount concern in 2002. Could a stun gun or other less-than-lethal device help a crew member thwart an onboard attack? In FY 2002, Congress directed NIJ to assess the use of less-than-lethal weapons aboard commercial aircraft as a means of incapacitating individuals posing a clear and present danger.<sup>11</sup>

The November 2001 Aviation and Transportation Security Act (ATSA) had required NIJ to conduct this assessment and provide a report to the Transport Secretary.<sup>12</sup> The report, entitled *Less-than-lethal Weaponry for Aircraft Security* and published in April 2002, was not made publicly available, however a summary of the findings was presented in a hearing to the US House of Representatives Committee on Transportation and Infrastructure in May 2002 by the then Director of NIJ, Sarah Hart.<sup>13</sup> The report considered electrical, chemical, blunt impact, light, and acoustic weapons as well as physical restraints. It concluded that electrical weapons, namely the Taser, showed the most promise but that kinetic impact projectiles may also be useful. It advised that more tests were needed on safety issues such as the effects of electrical weaponry discharge on aircraft equipment and the use of impact projectiles in confined spaces. The statement also noted that light (white light or laser light) and acoustic weapons needed more development before being considered, adding that light levels that are “truly disabling” often require power levels that cause permanent eye damage. As regards chemical agents the statement noted that a system for remote release of incapacitating chemical agents (such as anaesthetic drugs) to incapacitate everyone in the cabin, was under study or in development but acknowledged that there could be “unacceptable risks to the health of vulnerable passengers.”<sup>14</sup> The idea for such a system appears to originate from the US military. Several months earlier, in October 2001, the Director of the Joint Non-Lethal Weapons Directorate (JNLWD) had suggested this concept in a presentation to the US Airline Pilots Association, arguing that suitable incapacitating chemicals could be available in “3 years +”.<sup>15</sup> The NIJ study considered irritant chemical sprays to be insufficiently incapacitating against determined people.<sup>16</sup>

It later emerged that the use of “non-lethal” weapons had in fact played a role in the 11 September 2001 attacks. The 9/11 Commission Report, published in summer 2004, described reports of the use of ‘pepper spray’ to overcome passengers and flight attendants on both planes that eventually crashed into the World Trade Center.<sup>17</sup>

As it happens airlines have not sought to deploy “non-lethal” weapons on commercial aircraft in recent years. A May 2006 report published by the US Government Accountability office noted:

Due primarily to other enhancements in aviation security since 2001, there appears to be no demonstrated interest on the part of air carriers to introduce less-than-lethal weapons, including electric stun devices, on their aircraft.<sup>18</sup>

In addition to addressing aircraft security, the May 2002 statement by the Director of NIJ also gave a more general overview of the direction and focus of the Department of Justice programme on “non-lethal” weapons:

Through this program, NIJ seeks technologies that provide new or significantly improved less-than-lethal options to law enforcement and corrections professionals to enable them to reduce the number of deaths and injuries to suspects, prisoners, officers, and bystanders. The program is also designed to evaluate the safety and effectiveness of less-than-lethal weapons through laboratory and field demonstrations, and through the development of computer simulations and mechanical models.

Typically, NIJ-funded projects in this area have focused on:

- I. Improving the safety of blunt-trauma projectile weapons;
- II. Improving the delivery accuracy and dispersal efficiency of pepper spray for barricade scenarios;
- III. Evaluating the safety and effectiveness of pepper spray;
- IV. Developing and evaluating technology useful for disorienting suspects; and
- V. Evaluating the safety and effectiveness of electrical shock weapons.<sup>19</sup>

Further information on the status of the National Institute of Justice (NIJ) programme at that time is provided in a presentation by the NIJ to the Non-lethal Technology and Academic Research Symposium (NTAR) III in November 2001.<sup>20</sup> The presentation described the status of major development programmes at the time: the “Sticky Shocker” was undergoing further testing at the Air Force Research Laboratory (AFRL); the effects of the Laser Dazzler prototype had been assessed by the AFRL<sup>21</sup>; the Ring Airfoil Projectile (RAP) was receiving continued funding for development of a new launcher and the OC containing projectile; the WebShot (or Capture Net) had completed development; and a barricade penetrating projectile, designed to penetrate windows and then disperse OC was also under continued development. The presentation mentioned collaboration with the US Federal Aviation Administration (FAA) considering the use of the Taser and the Laser Dazzler on board aircraft as well as work on OC / incapacitating agent combinations and research on the ‘active light barrier’. In addition the presentation provided an overview of the perceived differences between military and law enforcement requirements for “non-lethal” weapons technologies, which underlie research and development efforts. This is reproduced in Table 1 below.

The law enforcement requirement for portable, cheap “non-lethal” weapons for use in one-on-one confrontations is notable. As regards specific weapons systems the presentation made reference to the differences in the permitted

use of chemical weapons.<sup>22</sup> Another important difference is the lower acceptance of injury in the law enforcement arena. This also ties in to issue of police liability for unwarranted injuries caused. As Boyd has argued:

These devices – at least when used by law enforcement – have to be effective, yet not sacrifice safety, where safety is defined as totally reversible effects with a duration no longer than is necessary. Unfortunately, the most effective technologies can push the bounds of safety, while very safe technologies are often not very effective at all.<sup>23</sup>

**Table 1:** National Institute of Justice assessment of the differences between law enforcement and military requirements for “non-lethal” weapons.<sup>24</sup>

End User	Military	Law Enforcement
Range	100 to 1000 ft.	0 to 100 ft.
Size/Weight	Vehicle mount or smaller	Person portable
Cost	Tolerate higher costs	\$500 or less
Operation	Crowd Control Area of denial (AOD) Tolerate preparation time	1-on-1 confrontation AOD – limited use Ready to use
Logistics	Personnel available for: Planning, set-up & maintenance Trained, practiced & specialised	Limited personnel: On belt or in trunk [boot] Trained Generalist
Use of Chemicals	Extremely Restrictive	Restrictive [ex RCAs]
Personnel Encountered	Men, women & children (non-military) “Good” physical condition	Men, women & children Alcohol & drugs a factor
Legal Implications	Global media present Non-citizen peacekeeping International law	Local/National media Citizen peacekeeping Local/State diverse laws

In February 2002 the National Institute of Justice released a solicitation for research on “non-lethal” weapons to be carried out in Fiscal Year 2002. It sought proposals for new or improved “non-lethal” weapons technologies as well as evaluation of existing technologies.<sup>25</sup> Reflecting the focus on ‘homeland security’ in the aftermath of the 11 September 2001 attacks they were looking for “non-lethal” weapons concepts for use in protecting public buildings or airports. As regards the weapons systems they wanted proposals for devices whose force or effects would be independent of range (i.e. to overcome the limitations of existing impact projectiles). They were also looking to fund development of multiple shot weapons and as well as small devices that could be easily concealed in a pocket.<sup>26</sup>

NIJ subsequently funded eight new projects for FY 2002 (see Table 2 below). Three of these projects involved testing and modelling to assess the injuries likely to be caused by kinetic energy impact projectiles, carried out at Wayne State University. Other research funded included: a project to develop a multiple-shot launcher for the Ring Airfoil Projectile (RAP); a one-year project assessing of eight different flash-bang devices, the report of which was published in 2003;<sup>27</sup> and a two-year assessment of how “non-lethal” weapons could be integrated into airport security. The latter project was completed in 2004.<sup>28</sup>

With regard to new weapons technologies NIJ also funded two projects being conducted in collaboration with the military. One of these was Phase II of continued development work on a “non-lethal” thermobaric or fuel-air explosive device with variable range. The first phase of this project to investigate the concept had been funded in 2000 and the final report of this work was published in 2002. The work was co-sponsored by Sandia National Laboratories and the National Institute of Justice, with two companies, Law Enforcement Technologies Inc. and Martin Electronics Inc., carrying out the development work with Sandia.<sup>29</sup> The second collaborative project was an assessment of the utility of a Multi-Sensory Grenade (MSG), originally developed for the Joint Non-Lethal Weapons Directorate (JNLWD), for law enforcement applications. This was to be carried out by the developer of this weapon, Scientific Applications and Research Associates, Inc. In 2003 one new project was funded, a study on injuries caused by various “non-lethal” weapons.<sup>30</sup> Table 2 below details all NIJ-funded projects on anti-personnel “non-lethal” weapons for fiscal years 2000 to 2006.

By late 2003 NIJ’s attention had turned to military directed energy weapons technologies and considerations of how they might be adapted for law enforcement applications. A November 2003 solicitation for FY 2004 research on Less-Lethal Technologies sought proposals for new “area denial” technologies:

The goal of research in this area is to enable law enforcement agencies to safely and effectively deny individuals or groups of people access to specific areas. An example could be the use of directed energy to induce an epidermal heating sensation in targeted persons.<sup>31</sup>

The example given was a reference to the Active Denial Technology (ADT) developed by the US Air Force in collaboration with Raytheon Company, who were subsequently awarded a \$500,000 contract for FY 2004 to work towards a prototype portable version of the technology for law enforcement use.<sup>32</sup>

Other directed energy weapons research funded by NIJ in FY 2004 included a \$360,000 award to Sterling Photonics for development of a portable pulsed laser weapon that would act by producing a plasma shock-wave.<sup>33</sup> This weapon development effort is similar to the US military’s Pulsed Energy Projectile (PEP), which is a much larger proposed vehicle mounted system. The Joint Non-Lethal Weapons Directorate also funded Sterling Photonics with over \$350,000 for non-lethal weapons development in 2004. Although there is no information on the details of this research it seems likely that they were contributing to the same project.<sup>34</sup> NIJ also awarded \$320,000 funding to the Air Force Research Laboratory in 2004 for development of a portable laser weapon system called the Portable Efficient Laser Testbed (PELT).<sup>35</sup> This award was not announced with the other funding awards detailed in Table 2 below because the project was classified at the time. The JNLWD also began funding this project in 2004.<sup>36</sup> This Air Force research effort has begun in-house during 2001 and in 2004 the name was changed from PELT to Personnel Halting and Stimulation Response (PHaSR). The PHaSR is being designed to employ a two wavelength laser system, one to heat the skin

of the target person and the other as a “dazzling” weapon against the eyes.<sup>37</sup> Another project funded (\$420,000) in 2004 was a laser “dazzling” weapon under development by Scientific Applications and Research Associates Inc. (SARA) called the Multiwave Dazzler.<sup>38</sup>

**Table 2:** National Institute of Justice funding awards relating to anti-personnel “non-lethal” weapons, fiscal years 2000-2006.<sup>39</sup>

Initial Funding	Additional Funding	Description	Contractor
(1996)	(1997), (1998), (1999), 2000	Less-Than-Lethal Technology Policy Assessment Panel	SEASKATE, Inc.
(1996)	(1998), (1999), 2000	Law Enforcement Technology, Technology Transfer, Less-Than-Lethal Weapons Technology, and Policy Liability Assessment	SEASKATE, Inc.
(1997)	(1998), (1999), 2000, 2001	Ring Airfoil Projectile System	Guilford Engineering Associates, Inc.
(1998)	(1999), 2000	Biomechanical Assessment of Nonlethal Weapons	Wayne State University
2000	-	Less-Than-Lethal Ballistic Weapon	Law Enforcement Technologies, Inc.
2001	-	Less-Than-Lethal Equipment Review <sup>40</sup>	National Security Research, Inc.
2001	-	Less-Than-Lethal Technology Support <sup>41</sup>	Pennsylvania State University
2002	-	Feasibility Study of a Finite Element Model to Assess Less-Than-Lethal Munitions <sup>42</sup>	Wayne State University
2002	-	Multisensor Grenade and Field Evaluation <sup>43</sup>	Scientific Applications and Research Associates, Inc.
2002	-	Multishot Launcher With Advanced Less-Than-Lethal Ring Airfoil Projectiles <sup>44</sup>	Vanek Prototype Co.
2002	-	Penetration Assessment of Less-Than-Lethal Munitions <sup>45</sup>	Wayne State University
2002	-	Performance Characterization Study of Noise-Flash Diversionary Device	E-LABS, Inc.
2002	-	Variable-Range Less-Lethal Ballistic, Phase II <sup>46</sup>	Law Enforcement Technologies, Inc.
2002	2005	Biomechanical Assessment of Blunt Ballistic Impacts to the Abdomen <sup>47</sup>	Wayne State University
2002	-	Analysis of Airport Security Measures and the Role of Less-than-Lethal Weapons <sup>48</sup>	National Security Research, Inc
2003	-	Injuries Produced by Law Enforcement Use of Less-Than-Lethal Weapons	University of Florida – Gainesville
2004	2005	Collection and Dissemination of Less-Lethal Databases to Law Enforcement	Pennsylvania State University
2004	-	Compact and Rugged Pulsed Laser Technology for Less-Lethal Weapons	Sterling Photonics, Inc.
2004	-	Independent Assessment and Evaluation of Less-Lethal Devices	Pennsylvania State University
2004	-	Injuries Produced by Law Enforcement's Use of Less-Lethal Weapons: A Multicenter Trial	Wake Forest University Health Sciences
2004	2005	Less-Lethal Weapon Technology Review and Operational Needs Assessment	Pennsylvania State University
2004	-	Modeling Electric Current Through the Human Body From a Less-Lethal Electromuscular Device	University of Wisconsin
2004	-	Multishot Launcher With Advanced Segmented Ring Airfoil Projectiles	Chester F. Vanek

2004	-	Ring Airfoil Projectile System: Operational Testing Guidance	Aerospace Corporation
2004	-	Multiwave Dazzler	Scientific Applications and Research Associates, Inc.
2004	-	Solid-State Active Denial System Demonstration Program	Raytheon Co.
2005	-	Analysis of Human Injuries and Taser Deployment: Effect of Less-Lethal Weapons in the De-escalation of Force	Florida Gulf Coast University
2005	-	Analysis of Less-Lethal Technologies: Taser Versus Stinger	Florida Gulf Coast University
2005	-	Effect of Taser on Cardiac, Respiratory, and Metabolic Physiology in Human Subjects	University of California–San Diego
2005	-	Human Electromuscular Incapacitation Devices in Trainees	New Jersey Medical School–Medicine and Dentistry
2005	-	Interdisciplinary Working Group for Review of Kinetic Energy Impact Injuries	Wayne State University
2006	-	Evaluation of Less-Lethal Technologies on Police Use-of-Force Outcomes	Police Executive Research Forum
2006	-	Injuries Produced by Law Enforcement's Use of Less-Lethal Weapons	Wake Forest University Health Sciences
2006	-	Electronic Control Weapons and Unexpected Deaths-in-Custody	International Association of Chiefs of Police

Two other projects funded in FY 2004 reflected the NIJ's stated requirement for research on "electromuscular device modelling" and "less-lethal device-induced injury data".<sup>49</sup> Researchers at the University of Wisconsin were given \$490,000 for a two-year project studying the flow of electrical current through the human body when exposed to electrical weapons such as the Taser<sup>50</sup> and Wake Forest University were funded for a two-year study to collect injury data relating to the use of electrical and kinetic impact weapons by police in the US.<sup>51</sup> There was also funding for two projects continuing the development of the Ring Airfoil Projectile (RAP) system.

Considerable funding was awarded in 2004 and 2005 to the Institute of Non-Lethal Defense Technologies (INLDT) at Pennsylvania State University for three projects in support of NIJ's "non-lethal" weapons programme, as shown in Table 3 below.

**Table 3:** Funding awarded by the National Institute of Justice for "non-lethal" weapons research at Pennsylvania State University.<sup>52</sup>

Contract	Funding 2004 (\$)	Funding 2005 (\$)	Total (\$)
Independent Assessment and Evaluation of Less-Lethal Devices (2004-IJ-CX-K013)	300,000	---	300,000
Collection and Dissemination of Less-Lethal Databases to Law Enforcement (2004-IJ-CX-K039)	113,481	250,000	363,481
Less-Lethal Weapon Technology Review and Operational Needs Assessment (2004-IJ-CX-K040)	202,000	300,000	502,000
<b>TOTAL FUNDING</b>			<b>1,165,481</b>



For some of these projects the specific nature of the research is unclear and further information is not provided by the NIJ in their annual reports. Presumably contract K039 involves creation and distribution of information on “non-lethal” weapons types, characteristics, uses, and effects. One project completed in FY 2004 as part of contract K040 where there is specific information available is statistical research on the outcomes of uses of electrical weapons such as the Taser to assess whether their use results in a reduction of deaths or injuries.<sup>53</sup> It is unclear what other “non-lethal” weapons assessments are funded by NIJ at the Institute of Non-Lethal Defense Technologies (INLDT). One possibility is further work on OC and incapacitating chemical mixtures that was ongoing in 2003. The Director of the INLDT certainly considered incapacitating chemicals amongst future “non-lethal” weapons technologies for law enforcement in a presentation to a NIJ conference in 2005.<sup>54</sup>

For fiscal year 2005 funding the National Institute of Justice issued two relevant solicitations. The first entitled *Less-Lethal Pursuit Management Technologies* called for proposals on:

- Developing new technologies to incapacitate personnel.
- Developing means to deliver effectively less-lethal force independent of range or environment.
- Acquiring, recording, and analyzing less-lethal device-induced injury data.<sup>55</sup>

And the second, entitled *Outcomes of Police Use of Force*, sought to fund research on “...relative likelihood of injury to officers, suspected offenders, and bystanders in situations where the police do or do not have access to less-lethal weaponry.”<sup>56</sup>

Subsequently NIJ funded five new projects on “non-lethal” weapons, as shown in Table 2. Four of these projects concerned electrical weapons (in particular the Taser) including studies of the human effects, impact on injuries resulting from police use of force, and comparison with the new Stinger electrical weapon. The other funded effort was a two-year project to establish a working group to review injury data from kinetic impact munitions.<sup>57</sup> No projects on new weapons technologies were announced although it is conceivable that classified programmes were funded.

In an October 2005 solicitation on “non-lethal” weapons the NIJ announced its’ specific intention to fund the development of new technologies during fiscal year 2006 rather than the evaluation of existing weapons:

NIJ seeks concept papers that describe the development of new, innovative devices that incapacitate individuals without risk of death or serious or permanent injury. NIJ is seeking devices that:

- Discretely incapacitate an individual (who may be in a crowd) at a distance.
- Compel near-instantaneous compliance at arms length.
- Compel one or more individuals to rapidly exit or not enter an area.

...

Possible Technical Approaches

Solutions to meet the needs described in this solicitation might include but are not limited to:

- Chemically based devices.
- Directed energy based devices.
- Conductive energy devices.<sup>58</sup>

Another solicitation for FY 2006 research entitled *School Safety Technologies* indicated that the NIJ was seeking to develop or adapt new “non-lethal” weapons for use in schools.<sup>59</sup>

Strangely, despite these calls for development of new technologies, the only funding awards that were announced for fiscal year 2006 were three new projects for work on the evaluation of safety and effectiveness of existing “non-lethal” weapons.<sup>60</sup> A two-year study began in May 2006 to assess the increasingly controversial area of deaths following the use of electrical weapons such as the Taser. The study, led by the NIJ and National Association of Medical Examiners, will comprise ‘mortality reviews’ by a panel of doctors to assess deaths that have occurred following the use of these weapons. In addition supporting field research will be carried out by the International Association of Chiefs of Police (IACP) to compare these cases with in-custody deaths not involving electrical weapons with a view to assessing the role of electrical weapons in reported deaths following their use.<sup>61</sup>

It is known that NIJ awarded \$250,000 to the Air Force Research Laboratory for continued development of a rangefinder for the PHaSR portable laser weapon that would aim to make it eye safe at varying distances. This work is being co-sponsored by the Joint Non-Lethal Weapons Directorate (JNLWD).<sup>62</sup>

Despite the range of “non-lethal” weapons projects funded by the National Institute of Justice, including research on new technologies, the impact of the NIJ programme on emerging weaponry is limited due to low funding in comparison to military sponsored research and development. NIJ funding for “non-lethal” weapons averaged \$1.5 million per year for the period fiscal year 2000 to 2006.<sup>63</sup> As a 2003 National Research Council report on “non-lethal” weapons science and technology argued:

The total research budget for non-lethal weapons development is modest, and the NIJ program has tended toward leveraging past R&D or modifying existing weapons to improve and extend effectiveness.<sup>64</sup>

More recently the US Department of Homeland Security (DHS) has begun to fund research and development of new “non-lethal” weapons through the Homeland Security Advanced Research Projects Agency (HSARPA). Their initial solicitation in January 2005 explained their particular goals and areas of interest:

Develop and demonstrate innovative less lethal devices for use by law enforcement officials that are inexpensive, safe, lightweight, man portable, and easy to use.

...

While proposals for all types of less lethal technologies will be accepted, the technology approaches of particular interest are radio frequency (RF), dazzlers (lasers or bright lights), or untethered electro-muscular disruptor devices.<sup>65</sup>

Subsequently five proposals were awarded \$100,000 for fiscal year 2005 to design a new device and three of these projects were later awarded further funding of \$750,000 for two-year research efforts to produce a prototype and conduct animal and human tests by early 2008. These projects are shown in Table 4 below.

**Table 4:** Funding awarded by the Homeland Security Advanced Research Projects Agency (HSARPA) for “non-lethal” weapons development.<sup>66</sup>

Initial Funding	Additional Funding	Description	Contractor
2005	2006-08	A Non-Lethal, Non-Tethered, Inexpensive Electro-Muscular Disruption Projectile	Lynntech, Inc.
2005	2006-08	Less-Lethal Eye Safe Handheld LED-Based Incapacitator for Law Enforcement	Intelligent Optical Systems, Inc.
2005	2006-08	Untethered Electro-Muscular Disruption Device	Mide Technology Corp.
2005	none	Inertial Capacitive Incapacitator	Physical Optics Corp.
2005	none	Innovative Electrostatic Energy Projectile Technology	UHV Technologies, Inc.

Two of the weapons projects selected for funding until 2008 concern electrical weapons. Lynntech are developing two types of electrical projectile, one to be fired from a 12-gauge shotgun and the other a larger 40mm projectile. Mide Technology are also developing a shotgun-fired electrical projectile. Intelligent Optical Systems are developing an optical weapon that produces very bright flashing light to cause flash blindness and disorientation that will apparently “operate at power levels close to the eye-damage threshold”.<sup>67</sup>

In the UK “non-lethal” weapons research has focused on the development of new kinetic impact projectiles and assessments of existing ‘off-the-shelf’ weapons as alternatives to the baton round. Following the recommendations of Independent Commission on Policing for Northern Ireland in 1999 a UK-wide Steering Group, comprising representatives from the Her Majesty’s Inspectorate of Constabulary, the Home Office, the Association of Chief Police Officers, the Ministry of Defence (MOD), the Northern Ireland Policing Board, the Police Scientific Development Branch (PSDB) [now the Home Office Scientific Development Branch (HOSDB)] at the Home office, the Defence Science and Technology Laboratory (Dstl), the Police Service of Northern Ireland, and chaired by the Northern Ireland Office, was set up in Summer 2000 with the following objective:

To establish whether a less potentially lethal alternative to baton rounds is available; and to review the public order equipment which is presently available or could be developed in order to expand the range of tactical options available to operational commanders.<sup>68</sup>

The work of the Steering Group has been conducted in five phases thus far. Although initially intended to address policing in Northern Ireland it soon expanded into a UK-wide activity. The Phase 1 report, published in April 2001, set out criteria against which proposed alternatives could be judged and

provided a literature review, conducted by the Police Scientific Development Branch (PSDB). The latter was supported by information from police and military organisations in the US, Canada and Europe, in particular the National Institute of Justice (NIJ).<sup>69</sup> Subsequently the Steering Group prioritised technologies for further research and tasked PSDB with carrying out initial testing and evaluation of these “non-lethal” weapons.<sup>70</sup> Meanwhile a new plastic baton round or ‘plastic bullet’, the L21A1, was adopted by the Army police in the UK and Northern Ireland in June 2001.<sup>71</sup>

The Phase 2 report of the Steering Groups’ work was published in November 2001. It incorporated PSDB’s initial evaluation research on various “non-lethal” weapons and also presented an initial medical assessment of “non-lethal” weapons. The latter was carried out by a subcommittee of the Ministry of Defence’s Defence Scientific Advisory Council (DSAC), the DSAC subcommittee on the Medical Implications of Less-lethal weapons (DOMILL). PSDB’s research provided the basis of recommendations for further research.<sup>72</sup>

By the time of the publication of the Phase 3 report over a year later in December 2002, the Steering Group ruled out all commercially available impact projectiles as alternatives to the baton round and had commissioned the MOD’s Defence Science and Technology Laboratory (Dstl) to develop two new projectiles: one with a crushable body to reduce the impact with the aim of reducing the risk of serious head injuries, the Attenuating Energy Projectile (AEP); and the other designed to deliver a CS irritant powder released from a frangible tip upon impact, the Discriminating Irritating Projectile (DIP).<sup>73</sup> The Phase 3 report also presented testing and evaluation carried out by PSDB on the M26 Taser, which had been given a high priority for further testing, and a medical assessment carried out by DOMILL.<sup>74</sup> The Phase 4 report<sup>75</sup> of the Steering Group was published in January 2004 and by that time the Association of Chief Police Officers (ACPO) proposal for an operational trial of the Taser M26 had been accepted and a one-year trial had begun in April 2003 with five police forces. Subsequently, in September 2004, use of the Taser was extended to firearms officers in all police forces in England and Wales.<sup>76</sup> In mid-2003 Taser International had introduced a new model, the Taser X26. Following evaluation by PSDB and medical assessment by DOMILL this was also approved for use by UK police forces in March 2005.<sup>77</sup> The Phase 4 report also discussed progress on development at Dstl of the Attenuating Energy Projectile (AEP), which was eventually introduced as a replacement for the L21A1 round in June 2005<sup>78</sup> and the Discriminating Irritating Projectile (DIP), which is still under development. At the time of writing the Northern Ireland Office published the Phase 5 report, which described the introduction of the AEP and noted that technical issues with regard to the DIP needed to be resolved but that it may be introduced in 2009 or 2010.<sup>79</sup>

Unlike the programme at the US National Institute of Justice (NIJ) the UK Home Office has not become involved in developing new technologies. PSDB, now the Home Office Scientific Development Branch (HOSDB) has

conducted extensive evaluation of existing “non-lethal” weapons but does not have the capacity for research and development of new technologies. Development of new kinetic impact projectiles has been carried out by the MOD’s Defence Science and Technology Laboratory (Dstl) who, together with the private company QinetiQ, are the primary centres for research on new “non-lethal” weapons in the UK.<sup>80</sup>

The UK Steering Group on “non-lethal” weapons maintains close ties with police and military organisations in Europe, Canada, and particularly the US. HOSDB has maintained an information sharing agreement with the US National Institute of Justice (NIJ) since 1997. Early on in its work the Steering Group forged close links with the Institute for Non-Lethal Defense Technologies (INLDT) at Pennsylvania State University (PSU), which led to the establishment by PSU of a collaborative forum called the International Law Enforcement Forum (ILEF) on Minimal Force Options. These are closed meetings with invited participants from police, military, and academic organisations involved in the development and use of “non-lethal” weapons for law enforcement in the US, UK, Canada, and Europe. The first two meetings were held at Pennsylvania State University in April 2001 and October 2002, the third was held in the UK at the Home Office Scientific Development Branch (HOSDB) in February 2004, and the fourth was hosted by the Royal Canadian Mounted Police (RCMP) in June 2005.<sup>81</sup>

### **3. Military Developments**

During 2000 the US military conducted a yearlong ‘Joint Mission Area Analysis’ (JMAA) for “non-lethal” weapons to assess the status of the Joint Non-Lethal Weapons Program (JNLWP). The conclusions of this study provided the direction for subsequent weapons development. It identified requirements in three weapons areas: counter-personnel, counter-materiel, and counter-capability. With regard to the former, four types of task were emphasised: control crowds; incapacitate individuals; deny area to personnel; and clear facilities, structures, or areas.<sup>82</sup> The study evaluated 45 potential “non-lethal” weapons technologies by assessing their promise for application to over 100 different types of mission and their flexibility in terms of delivery systems. Twelve of these were identified for further development:

1. millimeter wave
2. chemical oxygen iodine laser (COIL)
3. antitraction materials
4. non-lethal delivery and deployment
5. malodorants
6. calmatives
7. high-power microwave (HPM)
8. rigid foams
9. tagging and tracking
10. nanoparticles
11. laser scattering obscuration
12. deuterium-fluoride/hydrogen-fluoride (DF/HF) lasers.<sup>83</sup>

High priority was given to directed energy weapons concepts, the millimetre wave Active Denial Technology and high energy chemical lasers, and to new chemical weapons, namely incapacitating chemicals (so called “calmatives”) and malodorant chemicals.

The following year, in order to assess “non-lethal” weapons programmes and technologies in more detail, the Joint Non-Lethal Weapons Directorate (JNLWD) and the Office of Naval Research requested that the Naval Studies Board of the National Research Council (part of the US National Academy of Sciences) carry out an assessment of “non-lethal” weapons science and technology. A Committee with members from the US national laboratories, academia, and the private sector conducted a series of meetings during 2001, receiving briefings from the Marine Corps, Navy, Army, Air Force, and Special Operations Command, and published its final report in early 2003. The terms of reference for the study were that the committee should review existing programmes and technology areas and make recommendations for technologies that show promise for use by the US Navy and that should be pursued by the Office of Naval Research (ONR).<sup>84</sup>

The committee identified several technology areas that it considered to be most important for further investigation. In terms of anti-personnel weapons, they highlighted three areas in particular for investment: the development of incapacitating chemical weapons (so called “calmatives”) for use in “crowd control” and “clearing facilities”; accelerated research on directed energy weapons (in particular solid-state lasers for “operational non-lethal weapons applications”); and the use of unmanned vehicles (aerial, ground, and underwater) as delivery systems.<sup>85</sup> It should be noted that the committee also reviewed some classified projects. Although not discussed in the report the text did mention that classified research on lasers and on high-power microwave weapons was ongoing.<sup>86</sup>

With regard to chemicals the report recommended a “strong partnership” with the Army’s Edgewood Chemical Biological Center (ECBC), noting their prior work on such weapons and suggesting that the ONR contribution to such a partnership could be on “weaponizing” such agents, with attention to means to effectively stabilise and encapsulate the agents as well as systems to deliver and disperse them.<sup>87</sup> More specifically the committee recommended three steps. The first was to “identify opportunities for potential applications of malodorants”, arguing that more research was needed on the cultural variations in susceptibility, health effects and behavioural responses to these agents. The second was to “increase research in the field of human response to calmatives”, emphasising the development of agents with wide safety-margins apparently with the aim of altering behaviour or incapacitating without causing unconsciousness. The third was to “target efforts to develop chemical delivery systems”, noting that more advanced delivery systems were required to enable control of the ‘dose’ of chemical agent delivered.”<sup>88</sup>

Recommendations made by the committee with regard to anti-personnel directed energy weapons included urging careful assessment of the Active

Denial System (ADS) for naval applications cautioning that logistical, health effects, and effectiveness issues needed further investigation.<sup>89</sup> The committee was unimpressed with the two ongoing Joint Non-Lethal Weapons Directorate (JNLWD) chemical laser weapons programmes, the Pulsed Energy Projectile (PEP) and the Advanced Tactical Laser (ATL) and their final report argued that the JNLWD should “reassess its investments in these programs.”<sup>90</sup> However, they suggested that more research should be conducted on the potential of solid-state lasers for “non-lethal” weapons applications.<sup>91</sup>

The committee’s major recommendation for delivery systems was that programmes to use unmanned vehicles should be accelerated both for chemical and other payloads noting:

Considerable research in robotic and remote precision delivery of lethal weapons systems is well underway in many agencies. Small UAVs [unmanned aerial vehicles], UUVs [unmanned underwater vehicles] and remote controlled surface (water) vehicles offer attractive ways to deliver NLWs at large standoff distances with greater accuracy.<sup>92</sup>

More generally the committee recommended that the Joint Non-Lethal Weapons Directorate (JNLWD) should focus on two areas: encouraging and exploring new “non-lethal” weapon concepts and increasing efforts to characterise the effects and effectiveness of these weapons.<sup>93</sup>

The report stated that JNLWD had necessarily concentrated on relatively mature technologies and bringing commercial-off-the-shelf systems to the field but warned that the Directorate would soon run out of new “non-lethal” weapons ideas unless it refocused its attention. The reasons given for this were the limited funding for research and development, lack of understanding of human effects, and lack of resources for establishing the military effectiveness of these weapons.<sup>94</sup> With regard to new technologies the committee urged the JNLWD to “aggressively stimulate and explore new ideas”, recommending:

JNLWD build a significantly more robust outreach and exploratory investment program, to include partnerships with DARPA [Defense Advanced Research Projects Agency], U.S. government laboratories and law enforcement communities, and allies, as well as frequent interactions with the industrial base in which the directorate reiterates its requirements for potential developers.<sup>95</sup>

The committee pointed out that the limited funding available for research and development was insufficient to attract major defence contractors and national laboratories and recommended an increase of the \$500,000 funding for the JNLWD’s Technology Investment Program (TIP) by “an order of magnitude”.<sup>96</sup> By the time of the National Research Council report, several new projects had been funded under the Technology Investment Program (TIP):

- *Non-lethal loitering system.* An assessment of an autonomous delivery system for nonlethal applications.
- *Microencapsulation.* A demonstration of the ability to encapsulate non-lethal chemical payloads.

- *Front-end analysis.* A series of workshops and analyses culminating in a database of potential riot control agents and calmatives, with emphasis on technology advances in the past 10 years.
- *Thermobaric technology.* A feasibility study to determine the usefulness of thermobaric weapons to conduct non-lethal missions.
- *Veiling glare laser.* A study to demonstrate the ability of an ultraviolet laser to create a fluorescence-induced glare on excised human cadaver lenses.<sup>97</sup>

Recognising that the characterisation of human effects of various “non-lethal” weapons is central to acceptance by policy makers and military leaders, the committee argued for the creation of a ‘centre of excellence’ for each technology area (blunt impact, chemical, electrical etc.) to create models for assessing human effects drawing on relevant scientific expertise.<sup>98</sup> This would build on the existing Human Effects Center of Excellence (HECOE), which is based at and managed by the Air Force Research Laboratory’s Human Effectiveness Directorate at Brooks Air Force Base. The HECOE, established under a memorandum of understanding between JNLWD and AFRL in 2001, is the central organisation for “non-lethal” weapons human effects research.<sup>99</sup> The recommendation made by the National Research Council (NRC) panel is at the root of an emerging effects-based approach to “non-lethal” weapons research and development. In essence it is a form of reverse engineering, starting with the effect desired and then devising a mechanism to induce that effect.<sup>100</sup>

The report also drew attention to the major technical characteristics the authors considered desirable for a given “non-lethal” weapon. Two of the issues the report raised that are commonly expressed by military proponents include the perceived need for weapons with extended range up to hundreds of metres or even kilometres and the desire for weapons with scalable or rheostatic effects from “non-lethal” to “lethal”.<sup>101</sup> The latter approach clearly casts doubt on the validity of using the “non-lethal” terminology. The key technical characteristics discerned by the committee are shown in the list reproduced below:

Technical Characteristics of Non-Lethal Weapons<sup>102</sup>

1. Effects on target (significant, repeatable effects)
2. Rheostatic capability
3. Selective targeting
4. Portable by a person or existing vehicle
5. Standoff/range
6. Ease of cleanup
7. Developmental maturity
8. Complementary or synergistic technology
9. Acquisition and operational costs (training, maintenance, reuse, and so on)
10. Robustness to countermeasures

Aside from the findings on technological issues, the committee highlighted a broader issue with profound implications for the speed of development of new “non-lethal” weapons. That is a lack of genuine institutional support in the US Department of Defense (DOD) as a whole:



The committee finds a wide gap between the rhetoric on the importance of non-lethal weapons as expounded by senior leadership in the unified commands and the U.S. Marine Corps, and the limited attention in planning, assessment, R&D, and acquisition given to NLWs throughout DOD, in general, and the Department of the Navy in particular.<sup>103</sup>

One issue raised again with the publication of the National Research Council (NRC) report was that of the secrecy surrounding “non-lethal” weapons development. In the course of its study the NRC collected numerous documents relating to the wide variety of “non-lethal” weapons research and development efforts, which could shed further light on the status and focus of the programme including details of particular technological developments. As with all unclassified studies carried out by the US National Academy of Sciences, these background documents should have become US public records, available upon request. However, in 2002, prior to the publication of the report, the JNLWD instructed the National Academy of Sciences to withhold access to all of these documents and they remain unavailable to this day, although a few were obtained by The Sunshine Project before this action by JNLWD.<sup>104</sup> The history of “non-lethal” weapons development illustrates endemic secrecy surrounding many different aspects of these programmes. However, it seems likely that one area, that of continuing military interest in the development of new chemical weapons and its incompatibility with international law, is a major cause of this sensitivity. The preface to the NRC report notes that the differing interpretations of the prohibitions of the Chemical Weapons Convention within the US government, between the Department of Defense and the Department of State, led to the removal of the section on legal issues from the final version of the report.<sup>105</sup>

Of course the reason given for *de facto* classification of the public background documents collected for the NRC report was that security concerns following the attacks of 11 September 2001 precluded their release.<sup>106</sup> The NRC report had already been drafted when those events unfolded but the prologue to the report indicated that the field of “non-lethal” weapons, like every aspect of US defence and national security, would be reshaped and refocused in the light of the perceived new threat:

September 11, 2001, was a defining day in the history of the United States of America, if not the world. ...The implications for warfighting and law enforcement have yet to be fully understood, but most would agree that profound shifts in emphasis and investment are likely to come. In rooting out terrorism's infrastructure, there will be times when controlled application of force will be essential and unconstrained violence counterproductive to our strategic goals. ... As the immediate emotional circumstances fade, the need to isolate a few individuals, both in the United States and abroad, most likely in and amongst civilian populations, will remain critically important. In that context, non-lethal weapons may play an even greater role in matters of national security.<sup>107</sup>

As mentioned in the NRC report, another event that had begun to affect interest in “non-lethal” weapons amongst the US Navy was the attack US warship the USS Cole in October 2000.<sup>108</sup>

In late 2002 a senior Department of Defense advisory group, the Joint Requirements Oversight Council (JROC), approved a 'Mission Needs Statement' describing the development and acquisition of "non-lethal" weapons as a high priority, arguing that the US military lacked the capability to 'engage targets' in situations where the use of lethal force would be counterproductive. One of the major requirements they articulated was the development weapons with increased range suggesting various technologies that could be used such as frangible munitions, micro-encapsulation, and proximity fuses.<sup>109</sup>

In early 2003 the Council on Foreign Relations (CFR) embarked on a third study of "non-lethal" weapons, subsequently publishing the report of their findings in February 2004. Written during the development of the insurgency in the aftermath of the US-led invasion of Iraq, the report proposed that wider integration of existing "non-lethal" weapons amongst the Army and Marine Corps could have helped reduce the looting and sabotage and help re-establish law and order. Looking to the future the authors argued:

Incorporating these and additional forms of nonlethal capabilities more broadly into the equipment, training, and doctrine of the armed services could substantially improve U.S. effectiveness in achieving the goals of modern war.<sup>110</sup>

Similarly to the 2003 National Research Council study, the Council on Foreign relations found a lack of institutional support for "non-lethal" weapons at the top levels of the Pentagon:

We found little evidence that the value and transformational applications of nonlethal weapons across the spectrum of conflict are appreciated by the senior leadership of the Department of Defense. Despite successes on the small scale, NLW have not entered the mainstream of defense thinking and procurement.<sup>111</sup>

The report recommended that the Joint Non-Lethal Weapons Program (JNLWP) refocus on four areas. Firstly, noting that the primary users were currently the military police, it advocated the wider deployment of existing short-range "non-lethal" weapons (i.e. kinetic impact, Taser, flash-bang, etc.) in the Marine Corps and the Army, and also encouraged uptake of "non-lethal" weapons by the Navy and Air Force. Secondly the report recommended that the range of current "non-lethal" weapons should be extended beyond 100 metres, through development of precision delivery systems. Thirdly it urged that testing and human effects assessment of the millimetre wave Active Denial System (ADS) should be completed so that it could be fielded. Finally it called for increased funding and technical support for development of other "non-lethal" weapons such as the advanced tactical laser (ATL) and laser guided "non-lethal" payloads.<sup>112</sup> The CFR support for the ATL was in contrast to the unfavourable assessment by the National Research Council.

The CFR report also urged changes in the organisation of the JNLWP program and provision of funding, a major recommendation being that the Joint Non-Lethal Weapons Directorate (JNLWD) should be greatly expanded with a sevenfold increase in funding levels and greater support from the Joint Forces Command (JFCOM). For fiscal years 2000 to 2003 the JNLWD's core

budget had averaged at \$22 million per year. For fiscal year 2004 it had almost doubled to just under \$44 million but the CFR wanted to see an annual budget of \$300 million.<sup>113</sup> However, the budget has remained around \$44 million for fiscal years 2005, 2006, and 2007.<sup>114</sup> When set in the context of total US defence spending, the Joint Non-Lethal Weapons Program (JNLWP) really is a very minor effort, representing 0.01% of the \$440 billion defence budget for fiscal year 2007. With regard to funding development by industry the impression given at the JNLWP-sponsored *Non-Lethal Defense VI* conference in 2005 was of a deadlock on funding issues that could limit the speed of technological development, as described by Davison and Lewer:

Several speakers and panellists from the military made it clear that the Department of Defense (DOD) was not going to find extra funds for new NLW [“non-lethal” weapons] technology development, especially given the costs of current operations in Iraq and Afghanistan. They called on industry to invest in developing new systems assuring them that their products would be purchased if they help fill the military’s current ‘capability gaps’. For industry, however, this is a riskier strategy and they seek investment from the military to enable technology development.<sup>115</sup>

There are, however, some indications that overall funding for the Joint Non-Lethal Weapons Program (JNLWP) may increase again soon, perhaps doubling existing investment by 2013.<sup>116</sup>

Table 5 below illustrates the various “non-lethal” weapons currently employed by the US military. The majority of these weapons are furnished in the form of Non-Lethal Capability Sets (NLCS), which have been deployed since 1997, containing a set number of each item. The Army sets, for example, are designed to equip a platoon of 30 soldiers.<sup>117</sup> The “non-lethal” weapons included in the sets are primarily low-technology kinetic, chemical, optical, and flash-bang systems. However, a few new weapons, such as the M26 and X26 Tasers, have been added as they have become available. In addition to weapons the sets also contain various ‘riot control’ equipment such as batons, shields, plastic hand-cuffs, and bullhorns. By early 2004 around 80 of these sets had been deployed in various locations, including Iraq (six sets) and Kosovo, mainly with the Marines and the Army.<sup>118</sup> Several of the newer weapons are not included in the standard NLCS but have been fielded on a more limited basis such as the Long Range Acoustic Device (LRAD), the FN 303 launcher system, and the various laser “dazzling” weapons, all of which have been sent to Iraq. The FN 303 has now been designated as the current Individual Serviceman Non-Lethal System (ISNLS).<sup>119</sup>

It is notable that new “non-lethal” weapons that have been recently adopted by the military are primarily commercial ‘off-the-shelf’ technologies (Taser X26, LRAD, FN 303, green laser “dazzling” weapons) rather than the product of military sponsored research and development. The only anti-personnel weapons to have emerged from weapons programmes administered by the Joint Non-Lethal Weapons Directorate (JNLWD) itself are the Modular Crowd Control Munition and the 66 mm grenades.<sup>120</sup>

In terms of operational use by the military, the role of “non-lethal” weapons remains restricted. In Iraq, where the type of urban military operations often

used to promote the development of “non-lethal” weapons have been ongoing for several years, use of anti-personnel “non-lethal” weapons has been limited.<sup>121</sup> It seems the major area of employment has been their use as compliance tools in the control of prisoners. However, bright lights, laser “dazzling” weapons, Tasers, and Long Range Acoustic Devices have also been used in protecting convoys and stopping vehicles at checkpoints.<sup>122</sup>

**Table 5:** Current US military anti-personnel “non-lethal” weapons and delivery systems.<sup>123</sup>

Type	Weapon	Description / Manufacturer	Users
Kinetic	12 gauge shotgun rounds	Fin stabilised rubber, wooden, multiple rubber balls (Defense Technology Corp.), beanbag, dye containing (Technical Solutions Group)	Army, Marines, Navy, Air Force, Coast Guard
Kinetic	40mm M203 grenade launcher rounds	Multiple rubber balls, foam rubber baton (Defense Technology Corp.), sponge tip grenade (AMTEC)	Army, Marines, Navy, Air Force
Kinetic	Rifle-launched rounds	Multiple rubber balls ‘point’, multiple rubber balls ‘area’ rounds delivered at ranges of 30-80 metres (Alliant Techsystems)	Army
Kinetic	Rubber ball grenade	Hand grenade containing multiple rubber balls (Combined Tactical Systems)	Marines, Navy, Air Force
Kinetic	66 mm grenade Light Vehicle Obscurant Smoke System (LVOSS)	66mm multiple rubber ball grenade delivered at ranges of 80-100 metres (PW Defence)	Army, Marines
Kinetic	Modular Crowd Control Munition (MCCM)	Variant of claymore anti-personnel mine delivering rubber balls (Lone Star).	Army
Kinetic / Chemical	FN303 System (called the Individual Serviceman Non-Lethal System (ISNLS) by the military)	Compressed air launcher firing projectiles various projectiles with different payloads (solid kinetic impact, containing OC, and containing paint) (FN Herstal)	Army, Marines, Military Police
Chemical	Oloeresin capsicum (OC) spray	Various spray devices from small short range to large with range of 25 ft or more (Defense Technology Corp.)	Army, Marines, Air Force
Chemical	CR spray	Various spray devices from small short range to large with range of 25 ft or more (ACALA).	Army
Chemical	Grenade for 66mm Light Vehicle Obscurant Smoke System (LVOSS)	66mm L96A1 CS grenade with range of 65-95 metres (PW Defence).	Army
Electrical	Taser M26 / X26	Electro-shock stun weapon, also described as electro-muscular incapacitation (EMI) device (Taser International).	Army, Marines, Military Police
Optical	High intensity light	Fixed-mounted bright xenon or infrared flashlight to illuminate people at up to 1900 yards (Xenonics).	Army, Marines
Optical	High intensity light	Hand-held bright xenon flashlight to illuminate or obscure vision (Sure Fire).	Army, Marines
Optical / Acoustic	12 gauge shotgun round	Flash-bang round that produces a loud bang and bright flash to disorientate (Defense Technology Corp.)	Army, Air Force
Optical / Acoustic	Flash-bang grenade	Hand-thrown grenade that produces a loud bang and bright flash to disorientate (Universal Propulsion).	Army

Optical / Acoustic	66 mm grenade for Light Vehicle Obscurant Smoke System (LVOSS)	66mm flash-bang grenade that produces a loud bang and bright flash to disorientate at ranges of 80-100 metres (PW Defence).	Army, Marines
Acoustic	Long Range Acoustic Device (LRAD)	Directional high intensity acoustic device that can be used as loudhailer and also to cause ear pain and discomfort. Can cause ear damage at high power and close range. (American Technology Corp.).	Army, Marines, Navy, Military Police
Directed energy	Dissuader Laser Illuminator	Flashlight sized red laser diode “dazzling” weapon that causes glare or flash blindness but can cause permanent eye damage at close range (SEA Technology).	Air Force
Directed Energy	Various green laser “dazzling” weapons	Hand-held or weapon-mounted green laser “dazzling” weapons approved for use by the Army include: XADS PD/G-105 (Xtreme Alternative Defense Systems Ltd.), MiniGreen, GBD-IIIC (BE Myers & Co. Inc.), HELIOS, and GHOST.	Army
Delivery	12 gauge shotgun	Standard shotgun (Mossberg).	Army, Marines
Delivery	XM26 Lightweight shotgun system	Under-barrel shotgun attachment for standard rifle (C-More Systems).	Army
Delivery	40 mm M203 grenade launcher	Standard 40mm grenade launcher attachment for rifles such as the M16.	Army, Marines, Navy, Air Force
Delivery	66 mm Light Vehicle Obscurant Smoke System (LVOSS)	Vehicle mounted 66mm grenade launcher (Centech).	Army, Marines

The foci of ongoing weapons development programmes reflect the perceived need to increase the range and application of existing “non-lethal” weapons technologies and to incorporate new technologies with less emphasis on kinetic impact weapons. The major current US military programmes are shown in Table 6 below. In the area of electrical weapons efforts are directed at developing an electric-shock projectile that overcomes the range limitations of the Taser as well as continued development of electrical anti-personnel mine. The majority of programmes, however, relate to the development of directed energy weapons and new delivery systems. The millimetre wave electromagnetic Active Denial Technology (ADT) has been under development at the Air Force Research Laboratory (AFRL) since the early 1990’s and the main contractor, Raytheon, has been tasked with producing various different sizes of weapon incorporating this technology, one of which, called Silent Guardian, the company is already offering for sale.<sup>124</sup> Another weapon to emerge recently from AFRL is a dual-wavelength prototype laser weapon called the Personnel Halting and Stimulation Response (PHaSR). The third major anti-personnel directed energy programme is the pulsed energy projectile (PEP), which employs a pulsed laser to produce a high-energy plasma ‘shock wave’.

As regards delivery, programmes to mount “non-lethal” weapons delivery systems on military vehicles and unmanned ground vehicles are underway. There are several different types of munition under development, each designed to burst near or above the target person, group, or area and release a “non-lethal” payload. Although these munitions may be configured to release kinetic impact projectiles and flash-bang devices, there has been

particular attention to the employment of chemical payloads such as irritant agents (OC, PAVA, CS), malodorants, and incapacitating chemicals. PAVA, a synthetic form of OC, is under assessment for 'wide-area' dispersal for example.<sup>125</sup> Given the nature of these delivery systems and the types of chemical agents that have been proposed as payloads it would be strange if there was not an ongoing research programme to characterise and test these agents. It is unclear whether such research is being carried out under classified projects or whether policy concerns, relating to the prohibitions of the Chemical Weapons Convention (CWC), have prevented this from continuing. Whereas the 2003 National Research Council (NRC) report strongly advocated the further development of incapacitating chemicals, so called "calmatives", the 2004 report from the Council on Foreign Relations (CFR) cautioned against development of these biochemical weapons.<sup>126</sup>

**Table 6:** Major unclassified US military anti-personnel "non-lethal" weapon development programmes.<sup>127</sup>

Type	Weapon	Description	Main Developer <sup>1</sup>	Status
Kinetic	Mk19 Non-Lethal Munition (NLM)	Blunt trauma munition containing 1-3 plastic projectiles fired from Mk19 grenade machine gun. Ring Airfoil Projectile (RAP) also a potential payload. Long range version under development with 'flash-bang' payload.	ARDEC, JNLWD	R&D, prototype: ongoing testing.
Chemical	Mobility Denial System (MDS)	Lubricant chemicals to deny access to people (or vehicles) delivered from backpack or vehicle mounted spray device.	JNLWD, ECBC, Southwest Research Institute.	Prototype: ongoing testing of material and delivery systems.
Electrical	Taser Anti-Personnel Munition (TAPM)	Taser anti-personnel mine with range of 21ft triggered by infra-red sensors. Development as part of Army's Hand-Emplaced Non-Lethal Munition (HENLM) programme.	ARDEC, Taser International, General Dynamics-OTS	Prototype
Electrical	Extended Range Electronic Projectile (XREP)	Electrical projectile fired from 12-gauge shotgun with 30m range.	ONR, Taser International	Prototype: demonstrated in 2006 with limited human tests.
Optical / Acoustic	Joint Non-Lethal Warning Munition (JNLWM)	12 gauge and 40mm flash-bang munitions designed to discharge at fixed 100, 200, and 300m ranges.	NSWC Crane, JNLWD, Combined Systems Inc.	In production

<sup>1</sup> Acronyms as follows: Joint Non-Lethal Weapons Directorate (JNLWD); Army Research, Development and Engineering Center (ARDEC); Air Force Research Laboratory (AFRL); Naval Surface Warfare Center, Crane Division (NSWC Crane); Edgewood Chemical Biological Center (ECBC); Department of Justice (DOJ); Office of Force Transformation (OFT); Department of Energy (DOE); Office of Naval Research (ONR); and Army Research Laboratory.

Acoustic	"Acoustic Hailing Devices"	A number of acoustic devices that deliver directional sound at long range are under evaluation. They can be used for communication but can also cause ear pain and discomfort at high power levels and closer ranges.	ARDEC, JNLWD	Long Range Acoustic Device (LRAD) in use, other devices under consideration
Directed Energy	Active Denial System (ADS)	Vehicle-mounted millimetre wave directed energy weapon that causes pain through skin heating – 100 kilowatt, >750 m range.	AFRL, JNLWD, Raytheon Co.	Prototype: ongoing testing and evaluation.
Directed Energy	Silent Guardian	Fixed site or truck-mounted version of ADS for medium range applications – 30 kilowatt, > 250 m range.	Raytheon Co.	Offered for sale by company.
Directed Energy	Portable Active Denial System (PADS)	Tripod-mounted version of ADS – 400 watt, short range.	AFRL, DOE, OFT, Raytheon Co.	Prototype: ongoing human effects and utility testing.
Directed Energy	Handheld Active Denial System	Research towards the development of a handheld Active Denial weapon.	DOJ, JNLWD, Raytheon Co.	R&D
Directed Energy	Pulsed Energy Projectile (PEP)	Proposed weapon employing high-power pulsed chemical laser to create a plasma 'shock-wave' at the target surface (laser induced plasma).	JNLWD, Mission Research Corp.	R&D: ongoing development of laser hardware and human effects testing.
Directed Energy	Personnel Halting and Stimulation Response (PHaSR)	Laser weapon employing two wavelengths, one to 'dazzle' the other to 'repel' (possibly with heat). Formerly known as Portable Efficient Laser Testbed (PELT).	AFRL, JNLWD	Prototype: ongoing development of 'eye safe' rangefinder.
Delivery	Airburst Non-Lethal Munition (ANLM)	Munition that bursts just before it reaches a target, releasing the payload at 250 m range. Low and high velocity versions of 25mm and 40mm munitions under development. Payload may be chemical, kinetic impact, 'flash-bang' or electrical.	ARDEC, JNLWD, Pennsylvania State University, ECBC	R&D, prototype: ongoing testing and evaluation of payloads.
Delivery	81mm Non-Lethal Mortar	Development of a mortar round to deliver "non-lethal" payloads at ranges up to 2.5km. Primary consideration of chemical payloads through integration of Overhead Liquid Dispersal System (OLDS).	ARL, ECBC, United Defense	R&D, prototype: ongoing testing and evaluation of payloads.
Delivery	XM1063	155mm 'cargo round' containing numerous submunitions for delivery of various payloads at ranges of 15-25km. Liquid chemical payloads under consideration.	ARDEC, ECBC, General Dynamics-OTS	Prototype: ongoing testing and evaluation.
Delivery	Mission Payload Module – Non-Lethal Weapon System (MPM-NLWS)	Program to integrate a delivery system to vehicle platforms that will deliver a range of munitions, both lethal and "non-lethal" including smoke, flash-bang, and blunt impact. VENOM 40mm and Metal Storm systems under consideration.	ARDEC, JNLWD	System evaluation and human effects testing.
Delivery	Tactical Unmanned Ground Vehicle (TUGV)	Robotic ground vehicle designed as platform for remote control delivery of both lethal and "non-lethal" weapons. Various "non-lethal" payloads under consideration for integration.	JNLWD, ONR	Prototype TUGV in production, payloads available.

As is shown in Table 6, research and development activities under the Joint Non-Lethal Weapons Program (JNLWP) are spread across the military services, where research is conducted both in house and contracted out to the private sector. The Marine Corps funds research on “non-lethal” weapons at Pennsylvania State University (PSU), which is the designated Marine Corps Research University (MCRU). Much of this research is conducted by the Applied Research Laboratory, which operates a number of centres including the Institute for Non-Lethal Defense Technologies (INDLT). In addition to weapons research and development INDLT also carries out testing and evaluation and training activities. Projects also draw on expertise from other departments at the university including the College of Medicine.<sup>128</sup> The other major Marines research centre is the Non-Lethal Technology Innovation Center (NTIC) at the University of New Hampshire, which is tasked with identifying new “non-lethal” weapons technologies in the academic community.<sup>129</sup>

Within the Army, the Armament Research, Development and Engineering Center (ARDEC) at Picatinny in New Jersey remains the major site of “non-lethal” weapons research and development. In a similar vein to the Low Collateral Damage Munitions (LCDM) programme of the early 1990’s ARDEC’s Scalable Effects program seeks to develop weapons with variable effects from “lethal” to “non-lethal” and incorporates the development of new delivery systems as well as acoustic and directed energy technologies.<sup>130</sup> Within ARDEC the Target Behavioral Response Laboratory (TBRL) has been established as part of a ‘homeland defense’ initiative:

The TBRL looks at effects across the entire engagement spectrum from non-lethal to near lethal, from tactical scenarios to Homeland Defense (HLD)/Security (HLS) applications.<sup>131</sup>

In 2002 ARDEC established a research centre called the Stress and Motivated Behaviour Institute (SMBI) that brings together researchers from the Neuroscience and Medicine departments at the New Jersey Medical School.<sup>132</sup> Research at the SMBI concerns the neurobiological basis of stress and anxiety with the aim of developing new techniques of “personnel suppression” for the military and police. Current research is investigating the use of bright light and acoustic stimuli.<sup>133</sup>

The Army Research Laboratory (ARL) is also involved in “non-lethal” weapons R&D through joint efforts with ARDEC on delivery systems for “non-lethal” payloads.<sup>134</sup> ARL also conducts research into directed energy weapons for lethal and “non-lethal” applications.<sup>135</sup> The Army’s Edgewood Chemical Biological Center (ECBC) is the major centre of expertise with regard to chemical agents and is involved in development and evaluation of irritant agents (riot control agents), malodorants, and incapacitating agents.<sup>136</sup>

The Air Force Research Laboratory (AFRL) is the main site of “non-lethal” weapons R&D within the Air Force. AFRL’s Directed Energy Directorate at Kirtland Air Force Base in New Mexico is the US military’s centre of expertise



for directed energy weapons and whilst the focus is on lethal applications, “non-lethal” weapons are also under development.<sup>137</sup> The Active Denial System (ADS), for example, emerged from AFRL laboratories. Also the Directed Energy Bioeffects Division of AFRL’s Human Effectiveness Directorate (HED) at Brooks Air Force Base in Texas is the focal point for “non-lethal” weapons human effects research. There are three branches within the Directed Energy Bioeffects Division that are carrying out relevant work: the Joint Non-Lethal Weaponry Branch (HEDJ), the Optical Radiation Branch (HEDO) and the Radiofrequency Radiation Branch (HEDR).<sup>138</sup>

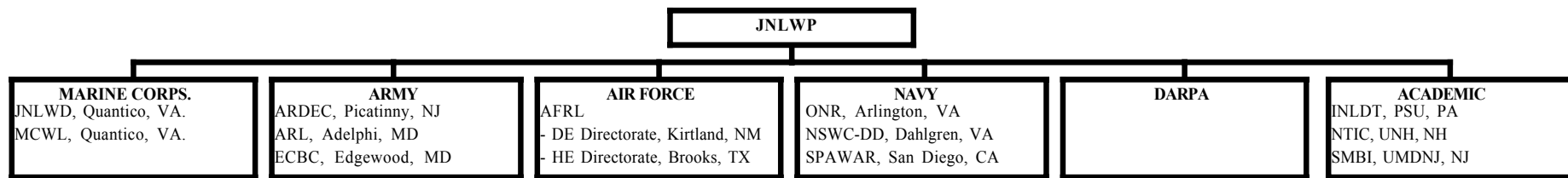
The main organisations conducting “non-lethal” weapons research within the Navy are the Office of Naval Research (ONR) and the Naval Surface Warfare Center (NSWC). In addition to coordinating the joint DOD-DOJ initiative on “non-lethal” weapons development, the Defense Advanced Research Projects Agency (DARPA) is also exploring some “non-lethal” weapons concepts, including those for urban combat operations.<sup>139</sup> The national laboratories of the Department of Energy, such as Sandia National Laboratories, also continue to carry out research on various “non-lethal” weapons projects. Chart 1 shows the main centres of military “non-lethal” weapons research and development, including military sponsored academic centres.

The direction and focus of ongoing research and development efforts can be gleaned from recent announcements soliciting proposals for research. In January 2006 the Joint Non-Lethal Weapons Directorate (JNLWD) was seeking proposals for applied research to develop ‘next-generation’ “non-lethal” weapons. According to the JNLWD the overall purpose of the research effort is to overcome perceived limitations of existing “non-lethal” weapons particularly with regard to: “range, accuracy and precision”; “effectiveness and the ability to quantify it”; “providing universal, repeatable and robust NL [non-lethal] effect”; and “target safety, particularly across a wide-spectrum of the population”.<sup>140</sup> As regards anti-personnel weapons the overall focus of research requirements was as follows:

- Develop novel non-lethal directed energy weapons.
- Develop long-range acoustic and/or ocular devices.
- Research and develop capabilities to incapacitate humans for extended durations (more than three minutes).
- Characterise the non-lethal human effects associated with non-lethal directed energy exposures.

Explore innovative non-lethal technologies and stimuli through the development of prototype systems and characterization of non-lethal human effects.<sup>141</sup>

**Chart 1: Military "non-lethal" weapons research and development actors.<sup>II</sup>**



<sup>II</sup> This chart does not show the organisational structure of the JNLWP, rather it indicates the main centres of military “non-lethal” weapons research and development.  
Acronyms: Joint Non-Lethal Weapons Program (JNLWP); Joint Non-Lethal Weapons Directorate (JNLWD); Marine Corps Warfighting Laboratory (MCWL); Armament Research, Development & Engineering Center (ARDEC); Army Research Laboratory (ARL); Edgewood Chemical Biological Center (ECBC); Air Force Research Laboratory (AFRL); Directed Energy (DE) Directorate; Human Effectiveness (HE) Directorate; Office of Naval Research (ONR); Naval Surface Warfare Center – Dahlgren Division (NSWC-DD); Space and Naval Warfare Systems Command (SPAWAR); Defense Advanced Research Projects Agency (DARPA); Institute for Non-Lethal Defense Technologies (INLDT); Non-Lethal Technology Innovation Center (NTIC); Stress and Motivated Behavior Institute (SMBI).

For fiscal year 2006 specific areas of research identified included the design of long-range acoustic and optical weapons and the further development of Active Denial Technology to enable smaller systems with lower power requirements as well as investigation of other millimetre wave frequencies. For fiscal year 2007 the research objectives include development of anti-traction materials, extended range wireless electrical weapons, and acoustic array systems as well as investigation of the human effects of various acoustic frequencies, incoherent light sources, and overpressures.<sup>142</sup> A overall goal for research is described as:

Develop next-generation non-lethal weapon capabilities and non-lethal payloads for extended duration incapacitation of humans and material at ranges in access of small arms range with little on no collateral damage.<sup>143</sup>

There is clear focus on directed energy and acoustic weapons technologies in the JNLWP's call for applied research as well as extending the range of existing technologies such as electrical weapons. There is no mention of the development of chemical weapons, namely riot control agents, malodorants, and incapacitating agents. However, new chemical agents are apparently foreseen as future "non-lethal" weapons capabilities, as has been articulated by the current Director of the Joint Non-Lethal Weapons Directorate (JNLWD).<sup>144</sup>

The way in which new directed energy, acoustic, and chemical "non-lethal" weapons are designed has begun to change with a focus on 'effects-based' weapons design underpinned by research on human effects. The Joint Non-Lethal Weaponry Branch (HEDJ) with the Directed Energy Bioeffects Division of AFRL's Human Effectiveness Directorate (HED) is at the centre of this reorientation. Essentially this group is carrying out and funding basic and applied research in order to characterize the physiological and psychological effects of various "non-lethal" weapons technologies on individuals and groups. The long term goal is to develop the theory and supporting predictive models to enable the design of new weapons based around a desired behavioural effect.<sup>145</sup> This research effort is very broad, seeking to investigate incapacitating effects that can be induced through interfering with the human senses of hearing, vision, touch and smell. It will also address the effects of electrical current on various physiological systems including the central nervous system, neuromuscular interface, and endocrine system. Perhaps most profoundly some research will seek to investigate suppressive effects on the central nervous system through, for example, influencing neurotransmitter function.<sup>146</sup>

Although the field of "non-lethal" weapons remains a niche area within the US Department of Defense (DOD) there have been signs in recent years of increasing institutional support. In February 2004 a Defense Science Board (DSB) report on *Future Strategic Strike Forces* advocated further development of "non-lethal" weapons affecting the physiological or psychological functions of individuals or populations as part of an expansion of weapons with disabling effects advising that "Applications of biological, chemical, or electromagnetic radiation effects on humans should be pursued."<sup>147</sup> In June

2005 the DOD's *Strategy for Homeland Defense and Civil Support* stated that "non-lethal" weapons would be further investigated for use in 'homeland defense'. Furthermore it noted that basic research into the physiological effects of "non-lethal" weapons would be expanded and that opportunities to share military technology with law enforcement agencies would be identified.<sup>148</sup> The report of the 2006 *Quadrennial Defense Review Report*, authored by senior leaders in the Department of Defense (DOD) and setting the tone for the future direction of the US military also articulates a role for "non-lethal" weapons as one of the capabilities required to achieve the major stated objective of "defeating terrorist networks".<sup>149</sup>

As regards international developments, in 1999 NATO had launched its Defence Capabilities Initiative (DCI) to align military capabilities with 'new security challenges' in which it would be involved such as the intervention in Kosovo.<sup>150</sup> As part of this NATO's Research Technology Organisation (RTO), formed in 1998 with the merger of the Advisory Group for Aerospace Research and Development (AGARD) and the Defense Research Group (DRG), was tasked with investigating "non-lethal" weapons technologies.<sup>151</sup> The RTO has conducted three technical studies, two carried out by its Studies, Analysis and Simulation (SAS) panel, and the other by the Human Factors and Medicine (HFM) panel. SAS-035, *Non-Lethal Weapons Effectiveness Assessment*, developed a mathematical model for assessing "non-lethal" weapon effectiveness. The report of this study was published in 2004 but is NATO restricted. Further work is ongoing under a follow on study: SAS-060 *Non-Lethal Weapons Effectiveness Assessment Development and Verification Study*, due to be completed in late 2007.<sup>152</sup> In December 2004 the SAS panel published the report of its study, *Non-Lethal Weapons and Future Peace Enforcement Operations* (SAS-040).<sup>153</sup> This technical study, based around a multi-national exercise in November 2003 assessed the types of "non-lethal" weapons technologies that would be most useful for NATO peace enforcement operations for the period up to 2020. Five technologies were identified as best suited to accomplishing various operational tasks: radiofrequency devices, rapid barriers (acoustic, electromagnetic, mechanical), anti-traction materials, electrical stun devices, and nets.<sup>154</sup> The report recommended that NATO should conduct focused research and development efforts in these five areas, noting:

These and other non-lethal technologies can be used in combination with each other to increase effectiveness and resistance to countermeasures and could be made scalable from non-lethal to lethal.<sup>155</sup>

A third technical study, *Human Effects of Non-Lethal Technologies* (HFM-073), was published in August 2006. It found a lack of information on human effects and recommended the formation of an international database of this information, arguing that these data were critical to public and military acceptance of new "non-lethal" weapons. It concluded that there was a particular need for human effects data concerning new "non-lethal" weapons concepts such as various directed energy weapons. The report recommended that follow-on work on human effects be conducted, focussing on the five technology areas identified in the SAS-040 study.<sup>156</sup>

#### 4. Irritant Chemical Weapons

Irritant chemical agents such as CS and oleoresin capsicum (OC) or 'pepper spray' continue to be used widely by police forces across the world, delivered by various spray devices, frangible projectiles, shells and grenades.<sup>157</sup> One of the most significant developments in recent years has been an increase in the usage of pelargonic acid vanillylamide (PAVA), a synthetic version of OC that is more potent and than the natural product and less variable in its potency. It is used widely by law enforcement organizations in North America and some European countries, including police forces in the UK who now use both CS and PAVA sprays<sup>158</sup> and the US military is also investigating its use.<sup>159</sup> There are enduring concerns over the safety and health effects of irritant chemical weapons and the variability of different products. For example, a study by the Medical Toxicology Unit of Guy's and St. Thomas' Hospital in London published in 2004 found that the specific CS sprays used by UK police forces may cause more adverse and long-lasting effects than other sprays.<sup>160</sup>

#### 5. Kinetic Energy Impact Projectiles

There are now a large variety of different impact projectiles that are commercially available to the police and military. Many of them are designed for use with a standard 12-gauge shotgun, 37mm launcher, or 40mm launcher. Others are fired with specially designed launchers such as the FN303 or the Pepperball system. A 2001 study carried out by the Applied Research Laboratory at Pennsylvania State University (PSU) tested 80 different projectiles and categorised them in seven broad classes: airfoil; baton (foam, plastic, rubber, styrofoam, wooden); drag-stabilized; encapsulated; fin-stabilized; pads; and pellets.<sup>161</sup> Despite the continuous use of impact munitions since the 1970's a major finding of the PSU study was the "general inaccuracy" of these types of "non-lethal" weapons. A similar study conducted by the UK 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.<sup>162</sup> Accuracy is a major concern because many of these munitions can cause serious injury or death if they hit a sensitive part of the body such as the head and neck. The 2003 National Research Council report on "non-lethal" weapons noted: "control of trauma level from blunt projectiles remains a serious problem."<sup>163</sup> An October 2004 US National Institute of Justice (NIJ) report entitled *Impact Munitions Use: Types, Targets* noted that the range at which a munition is fired is a key factor in the severity of the injury caused. The report pointed out that bean-bag and plastic baton rounds were the most commonly used types of impact projectiles by US law enforcement.<sup>164</sup>

In the UK in 2001 the L5A7 plastic baton round (plastic bullet) was replaced with the L21A1 round, which had been under development since 1997 and was designed to be more accurate and therefore reduce the likelihood of causing death or serious injury.<sup>165</sup> However, a March 2003 report published by the Northern Ireland Human Rights Commission (NIHRC) found that the

new round hit harder, was 2.5 times more likely to penetrate the skin, and had a higher potential for ricochet than the old round. Moreover it found that the new round was more likely to cause injury, with 10.3% of the new rounds having caused injury compared to 1.14% of the old L5A7 rounds.<sup>166</sup> Subsequently the Defence Science and Technology Laboratory (Dstl) developed the Attenuating Energy Projectile (AEP) as a replacement for the L21A1 plastic baton round. The AEP, introduced in June 2005, is a plastic projectile with an 'air pocket' that causes it to crush on impact with the intent of reducing the likelihood of death or serious injury.<sup>167</sup> It was used extensively in Northern Ireland during riots in late 2005.<sup>168</sup> The first medical study of injuries caused by the AEP was published in 2007 and found concluded:

The stated objective for the AEP development and introduction was to decrease the possible risk of serious or fatal head injury. Although no deaths were attributable to the use of the AEP, a combined total of 50% of the injuries sustained were to the thorax or above the clavicle. In this context, is it fair to ask if there is such a thing as a "safer" head injury? It is clear that the AEP requires ongoing evaluation, and it is too early to conclude that it provides a safer alternative to the L21A1.<sup>169</sup>

## **6. Electrical Weapons**

Since the introduction of a higher-powered and more effective model by Taser International in late 1999 Taser electrical weapons have proliferated in law enforcement agencies in the US and world-wide. According to the company by October 2006 they had sold 184,000 Tasers to 9,100 law enforcement and US military agencies, including law enforcement agencies in 44 different countries.<sup>170</sup> They are widely used by police across the US and Canada, have been adopted in the UK for use by firearms officers. In 2003 Taser International introduced a new model, the X26, which apparently improves on the effectiveness of the M26 model. A variety of cartridges are sold by the company with ranges of 15, 21, 25, and 35 feet and longer barbs have been developed for use against people wearing thick clothing.<sup>171</sup>

The company sells a version of the latest Taser, called the X26c, to the general public for 'personal defence'. Furthermore, in 2007 the company is introducing another electrical weapon called the Taser C2, which is aimed at expanding their consumer market. It is smaller (and therefore easily carried), cheaper, and does not look like a weapon (it comes in a variety of colours including metallic pink).<sup>172</sup> Both police groups such as the International Association of Chiefs of Police (IACP) and human rights organisations including Amnesty International have expressed concern over this step towards the wider marketing and availability of electrical shock weapons.<sup>173</sup> Criminal use of electrical and other "non-lethal" weapons for crimes such as robbery, assault, and rape is already widespread in the US and elsewhere.<sup>174</sup> Furthermore, such weapons are inherently suitable for carrying out these crimes. In the US possession is permitted in the majority of States. As Davison and Lewer have argued:

A combination of suitability for crime and availability is a dangerous one. ... Without controls on public availability, crimes facilitated with non-lethal weapons will increase.<sup>175</sup>

For the military Taser has developed the X-Rail System, which attaches a Taser X26 stun gun to rifles. Earlier models were developed for use by the military in Iraq and Afghanistan.<sup>176</sup> In August 2006 the company announced the formation of an advisory board of former military officers indicating that it hopes to expand sales to the military.<sup>177</sup>

For a while Taser International was the only company making this type of electrical weapon, having acquired its main competitor, Tasertron, in June 2003. However, more recently a company called Stinger Systems has started selling similar wire-tethered electrical stun weapons, having developed two-shot and four-shot models.<sup>178</sup> The same company also sells stun-belts, so called "prisoner worn stun devices", to US law enforcement and military agencies. Such systems are banned in the European Community under legislation that classifies them as torture devices.<sup>179</sup>

Little medical testing of the new Taser weapons was carried out prior to their wide introduction across North America but increasing concerns over deaths following the use of Tasers, as raised by various organisations including Amnesty International, have led to further research sponsored by the US Department of Justice and Department of Defense.<sup>180</sup> Concerns remain over the human effects of Taser electrical weapons, particularly in relation to the administering of multiple shocks, use on those under the influence of drugs, and use on children or other vulnerable groups. Moreover there is unease that the weapons are not being employed as an alternative to lethal force but as a compliance tool for police.<sup>181</sup>

Ongoing research and development of electrical weapons in recent years has focussed on longer range systems. The US Office of Naval Research (ONR), on behalf of the Marines, has funded development by Taser International of a projectile that delivers an incapacitating electric shock. A prototype of the XREP (eXtended Range Electro-Muscular Projectile), which is fired from a 12 gauge shotgun, was demonstrated to the military in February 2006 at ranges of 30 metres.<sup>182</sup> As described earlier in this chapter the US Homeland Security Advanced Research Projects Agency (HSARPA) is also funding the development of electric-shock projectiles through contracts with Lynntech and Mide Technology. In the private sector the MDM Group is developing rubber bullets that deliver an electric shock under the name 'ShockRounds'.<sup>183</sup>

Taser International has also been developing an electrical anti-personnel mine in collaboration with the US Army and General Dynamics Corporation.<sup>184</sup> It is referred to by the military as the Taser Anti-Personnel Munition (TAPM) and by the company as the Taser Remote Area Denial (TRAD) system and it is being marketed to both the military and police to protect buildings and facilities or deny access to an area. The TRAD will fire multiple Taser cartridges triggered by motion sensors and an infra-red camera, and software has been

developed to network a number of the devices together to cover a wide area.<sup>185</sup>

## **7. Other Technologies**

The National Institute of Justice (NIJ) has been funding the development of a new 'flash-bang' weapon to replace existing grenade-type devices in use for over thirty years, which combine bright light and painful sound levels to disorientate. The weapon, under development at Sandia National Laboratories, releases a cloud of powdered fuel that is ignited to form a bright fireball, loud noise, and pressure wave in the same manner as a fuel-air explosive or thermobaric weapon. The developers are working on a fusing system that would enable it to detonate next to the victim at ranges of 15 to 100 metres and there are plans to incorporate a chemical irritant agent as well.<sup>186</sup>

At the point of detonation, the resulting flash-bang effects could be terrifying to an adversary. The target would be confronted with an exceptionally bright fireball at least two meters in width that would appear to totally envelop him. The acoustical report would probably create intense pain in the adversary's ears. The shock wave of 2.5 to 3.0 psi would probably create more terror. And if the ballistic contains a chemical irritant, it would cause the adversary even greater disorientation and discomfort.<sup>187</sup>

With sound levels of up to 170 db the device would present a serious danger of permanent hearing damage.

Several other weapons are under development that combine a number of different effects to target multiple human senses.<sup>188</sup> One technology development effort of the Joint Non-Lethal Weapons Program (JNLWP) aims to produce a so called "clear-a-space device" to cause people to evacuate a building without having to enter it.<sup>189</sup> Under this programme Scientific Applications and Research Associates Inc. (SARA) have been developing a "multi-sensory grenade" that produces a bright flash, loud noise, and also releases a malodorant or other chemical agent. It also has a modular design that may allow for incorporation of other technologies in the future.<sup>190</sup> The US National Institute of Justice (NIJ) has funded an evaluation of this weapon for civilian use to control the movement of individuals or crowds.<sup>191</sup> In 2004 the Marines were soliciting ideas for a "clear-a-space device" that light, sound, and kinetic impact projectiles.<sup>192</sup>

Continued development of a system to deliver anti-traction materials, called the Mobility Denial System (MDS), has been funded under the Joint Non-Lethal Weapons Program (JNLWP). The Southwest Research Institute (SwRI) in Texas has developed a prototype system that sprays a highly slippery gel, formed from a mixture of polymers and water, onto surfaces to restrict the movement of people or 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.<sup>193</sup> 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.<sup>194</sup> One concern with the use of anti-traction materials 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.<sup>195</sup> Researchers at the Emulsion Polymers Institute at Lehigh University in the U.S. have been working on the microencapsulation of anti-traction materials.<sup>196</sup> 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.<sup>197</sup> This technology is also being applied to the delivery of other chemical agents such as incapacitating agents and malodorants.

As regards chemical weapons, there has been ongoing research and development of malodorants and incapacitating agents. Malodorant chemicals continue to be considered as potential payloads for chemical delivery systems under development by the Joint Non-Lethal Weapons Program (JNLWP) and the National Institute of Justice (NIJ). Building on research initiated in the late 1990's the Army's Edgewood Chemical Biological Center (ECBC) have continued to investigate these agents in partnership with the Monell Chemical Senses Center in Philadelphia. Research has been conducted on cultural differences in susceptibilities to different odours.<sup>198</sup> The 2003 National Research Council report on "non-lethal" weapons argued that malodorants "...have a strong potential for controlling crowds, clearing facilities, and area denial" and recommended further research.<sup>199</sup> More recently development of these agents has been advocated strongly by both military and law enforcement groups.<sup>200</sup> 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."<sup>201</sup> Apparently police forces in the US have begun to use foul smelling materials to prevent occupation of vacant buildings.<sup>202</sup>

Research and development of incapacitating biochemical agents has continued in recent years with interest from the US military and the US Department of Justice in using these agents as payloads for various delivery systems. Given the controversial nature of research in this area, especially with regard to military involvement, little information is available on research efforts. In 2000 the Joint Non-Lethal Weapons Directorate's Technology Investment Program (TIP) funded a 'Front End Analysis' of anti-personnel

chemicals at the Edgewood Chemical Biological Center (ECBC) with the objective identifying chemicals for “immobilizing adversaries”.<sup>203</sup> The Applied Research Laboratory (ARL) at Pennsylvania State University, who have worked with the U.S. military and law enforcement agencies on “non-lethal” weapons since 1997, carried out a literature review to assess the potential of incapacitating agents based on the available literature. The report, *The Advantages and Limitations of Calmatives for Use as a Non-Lethal Technique*,<sup>204</sup> was published in October 2000.<sup>205</sup> The front end analysis was ongoing in fiscal year 2001/02.<sup>206</sup> The National Research Council report in 2003 strongly advocated further development of incapacitating agents noting that such chemicals were being studied at ECBC after a “...lull in R&D for 10 years.”<sup>207</sup> Research and development work is progressing elsewhere including in Russia.<sup>208</sup> In Moscow in late 2002 when Russian authorities ended the siege of a theatre using an aerosolised fentanyl derivative<sup>209</sup> with devastating results.<sup>210</sup> In the Czech Republic the military have teamed up with anaesthesiologists to carry out research and development of different mixtures of agents with a focus on opioids, alpha-2 agonists, and dissociative anaesthetics such as ketamine.<sup>211</sup>

Despite research attempting to harness acoustic energy for use as weapons, few devices have emerged. It has proved difficult to produce acoustic energy in a directional beam and there are no proven effects of non-audible frequencies, infrasound and ultrasound, or viable effects of audible frequencies at levels that do not risk hearing damage. As a result research programmes conducted by the Army Research and Development Engineering Command (ARDEC) in collaboration with private sector companies such as SARA Inc. were halted by the Joint Non-Lethal Weapons Directorate (JNLWD) in the late 1990's. The major development in this field has come from the commercial sector. American Technology Corp. have developed a device, comprising an array of acoustic emitters, for projecting loud audible sound over long distances (up to 1km), called the Long Range Acoustic Device, first introduced in 2003.<sup>212</sup> The device transmits speech or recordings but also has a piercing warning tone. Referred to by the military as an “acoustic hailing device” rather than a weapon, it can be used in this manner but at high power levels and close ranges it can cause ear discomfort and permanent hearing damage.<sup>213</sup> As of September 2005 around 350 LRAD systems had been deployed, primarily with US military and law enforcement agencies.<sup>214</sup> A number of other companies have developed similar systems<sup>215</sup> and the Joint Non-Lethal Weapons Directorate (JNLWD) has been evaluating some of these.<sup>216</sup> ARDEC has also continued research and development of its' own Aversive Audible Acoustic Device (A3D) and has also working with American Technology Corp. and the Stress and Motivated Behavior Institute (SMBI) to investigate the “aggressive” use of the LRAD as a weapon rather than a hailing device.<sup>217</sup> Research has continued in the US and other countries on the development of vortex ring generators for use as projectiles or as a delivery system of various payloads including irritant chemicals.<sup>218</sup> The most recent JNLWP announcement on applied “non-lethal” weapons research placed considerable emphasis on acoustic weapons.<sup>219</sup>

Research and development of directed energy weapons has intensified in recent years. Predominantly efforts are focused on lethal systems with the aim of exploiting the military potential of directed energy to achieve asymmetric technological advantage over adversaries. The majority of funding is allocated to systems such as the Boeing 747-mounted Airborne Laser for missile defence,<sup>220</sup> and high-power microwave systems designed to destroy electronic equipment.<sup>221</sup> Nevertheless significant research and development work is being conducted on anti-personnel “non-lethal” weapons that employ various types of electromagnetic energy: radiofrequencies, low energy lasers, and high energy lasers. In the case of high energy lasers, some work is barely distinguishable from research on “lethal” systems. Moreover directed energy weapons are seen by the military and law enforcement as the future of “non-lethal” weapons in part because they provide the most promising opportunity to develop rheostatic weapons with variable effects from “lethal” to “non-lethal”.<sup>222</sup> The major US military programme is the Active Denial System (ADS), which employs millimetre wave energy to heat the skin, causing a painful burning sensation. A prototype ADS System 0 was developed by the Air Force Research Laboratory and declassified in late 2000. In recent years a vehicle-mounted ADS System 1 has been undergoing human testing and military evaluation but despite reports of its imminent use in Iraq,<sup>223</sup> it will not be deployed until 2010 at the earliest.<sup>224</sup> Raytheon Corp., which built the prototype for the JNLWP has been developing three smaller versions of this weapon, one of which, called the Silent Guardian, was being offered for sale to military and law enforcement agencies as of October 2006.<sup>225</sup> Another major US military development programme is the Pulsed Energy Projectile (PEP), which would theoretically employ a high energy pulsed chemical laser to produce a plasma blast wave stimulating nerves in the skin to cause pain and incapacitation.<sup>226</sup> An additional high energy chemical laser system is the aircraft-mounted Advanced Tactical Laser (ATL), jointly funded by the JNLWP and the Special Operations Command (SOCOM). It is promoted as a “non-lethal” anti-materiel weapon not because it would lack destructive effect but because it would apparently enable precise targeting. Describing it as a “non-lethal” weapon is akin to classifying a rifle firing bullets as “non-lethal”. Furthermore, nothing prevents it being used as a “lethal” anti-personnel weapon.

Development of a variety of low energy laser “dazzling” weapons by the US military, the Department of Justice, and private companies has continued. Many of these types of laser weapons, whilst “dazzling” at a certain range can cause permanent eye damage at shorter ranges. Some green laser “dazzling” weapons are already in use by the US military in Iraq and a prototype system, called the Personnel Halting and Stimulation Response (PHaSR), that fires two different laser wavelengths, one to “dazzle” and one to heat the skin, has recently been revealed by the Air Force Research Laboratory.<sup>227</sup> Another research area promoted by several companies and funded by the US military is the use of lasers to produce an ionised plasma along which an electrical charge is conducted to incapacitate or kill.<sup>228</sup> The primary goal of JNLWP-sponsored applied research on “non-lethal” weapons is to develop new directed energy systems.<sup>229</sup>

With the range of existing “non-lethal” weapons seen as a major limitation, a significant number of US military research and development programmes are on new munitions, including shells, grenades, and mortars, that may enable delivery of various payloads at greater ‘stand-off’ distances whilst minimizing injury from the munition casing. There has been particular attention to the delivery of various chemical agents including irritant chemicals, malodorants, and incapacitating agents. In the private sector frangible encapsulated projectiles containing irritant chemicals for use against individuals, such as those fired by the Pepperball and FN303 systems, have been adopted by law enforcement agencies and more recently by the US military.<sup>230</sup> The UK Defence Science and Technology Laboratory (Dstl) is developing a similar chemical delivery system for irritant chemicals called the Discriminating Irritant Projectile (DIP). Their research so far indicates a preference for a frangible projectile containing powdered CS mixed with silica powder.<sup>231</sup> Unmanned air vehicles are being increasingly deployed by the US military in their operations and other unmanned platforms that have been developed include surface watercraft, underwater vehicles and ground vehicles. Whilst unmanned platforms have primarily been developed for use in sensing, surveillance or “lethal” weapons delivery, they are under consideration for delivering “non-lethal” payloads.<sup>232</sup>

## **8. Legal Issues**

No new international agreements that relate to “non-lethal” weapons have emerged in recent years; however debates surrounding the impact of these new weapons on existing arms control treaties and international humanitarian law have intensified.<sup>233</sup> Fidler has argued that there are three perspectives on the future of “non-lethal” weapons and international law:

The compliance perspective insists that NLWs [“non-lethal” weapons] comply with existing rules of international law. The selective change perspective seeks limited changes in international law to allow more robust use of NLWs. The radical change perspective sees in NLWs the potential to reform radically international law on the use of force and armed conflict.<sup>234</sup>

He has pointed out that technological development will continue to stress international law on the development and use of these weapons in ways that are “politically charged, legally complicated, and ethically challenging”.<sup>235</sup>

Much of the debate in recent years has centred on the development and proposed usage of incapacitating biochemical weapons and their associated delivery systems. This intensified following the siege of the Moscow theatre in 2002 where Russian Special Forces used incapacitating agents for the first time killing over 120 people. However, the subject was intentionally avoided at the First Review Conference of the Chemical Weapons Convention (CWC) in early 2003,<sup>236</sup> and it remains to be seen whether States address this issue at the Second Review Conference in 2008. The issue has also been raised in peripheral discussions in relation to the Biological Weapons Convention (BWC) since proposed biochemical weapons agents may be covered by both

conventions.<sup>237</sup> As regards the CWC, events in Moscow refocused attention on the permitted uses of chemical weapons for 'law enforcement purposes' and differing interpretations over which types of chemicals are permitted in which types of circumstances.<sup>238</sup> Continuing military interest in these weapons is seen as the greatest threat to the prohibitions of the CWC and the BWC and the established norms outlawing chemical and biological warfare.<sup>239</sup>

The age old issue of military use of irritant chemical weapons or riot control agents (RCA) has come to the fore again in recent years. In 2003, in the run up to the ongoing war in Iraq, US Secretary of Defence Donald Rumsfeld testified to the US Congress House Armed Services Committee, stating that US was attempting to "fashion rules of engagement" to enable their use in combat<sup>240</sup> despite the fact that the Chemical Weapons Convention (CWC) prohibits the use of riot control agents "as a method of warfare".<sup>241</sup> This notion is unsupported by all other countries, including the UK. The Defence Secretary Geoff Hoon made it clear that the UK military would not use RCAs in any military operations or on any battlefield.<sup>242</sup> There is even disagreement within the US government on this issue with the Department of State in opposition to calls by the Department of Defense (DOD) for wider military use of RCAs. And indeed military development of new incapacitating agent weapons.<sup>243</sup> Nevertheless the DOD continues to press for changes to policy.<sup>244</sup> A related issue is the legal status of malodorants. Indications from the US military suggest a keenness not to classify them as riot control agents, which would prohibit their use in warfare.<sup>245</sup> However, if they were deemed sensory irritants then they may indeed be classed as riot control agents and subject to the prohibitions and restrictions of the CWC.<sup>246</sup>

For emerging acoustic and directed energy weapons, however, there are no international agreements restricting their development and proliferation beyond compliance with international humanitarian law, and the additional protocol to the Convention on Certain Conventional Weapons (CCW) that prohibits laser weapons intentionally designed to blind. Military establishments are keen to resist additional constraints on the development and use of "non-lethal" weapons technologies, as exemplified in a recent NATO report:

In order to ensure that NATO forces retain the ability to accomplish missions, it will be important that nations participating in NATO operations remain vigilant against the development of specific legal regimes which unnecessarily limit the ability to use NLWs.<sup>247</sup>

Another consideration surrounds the ever increasing tendency of the military to refer to "non-lethal" weapons not as weapons but as "capabilities" or "technologies", which extends to individual types of weapons. This semantic strategy is largely for policy and public relations effect in gaining acceptance of new weapons or even prohibited weapons (in the case of biochemical weapons). However, it seems there have been legal implications. The Long Range Acoustic Device (LRAD) has avoided the military legal review that is required for all new weapons systems apparently because it not classified by the US military as a weapon.<sup>248</sup>

In late 2006 the International Committee of the Red Cross (ICRC) published a document to assist states in ensuring new weapons and means of warfare comply with the fundamental principles of the law of war and treaties prohibiting specific weapons.<sup>249</sup>

## **9. Conclusion**

At the turn of the century, with the Joint Non-Lethal Weapons Program (JNLWP) less than four years old, the military set out to assess progress and set priorities for research and development. The Joint Mission Area Analysis (JMAA) in 2000 and the National Research Council (NRC) review in 2001, concurred on the required focus of technological development: directed energy weapons (lasers and radiofrequency devices), chemical weapons (incapacitating agents and malodorants), and delivery systems (particularly unmanned platforms). A review carried out by the Council on Foreign Relations (CFR) in 2003 broadly agreed with these assessments. Notably, however, the CFR authors disagreed on the issue of incapacitating agents, arguing that the costs of pursuing new biochemical weapons outweighed the benefits. Both the NRC and the CFR authors emphasised the broader perceived requirement for weapons with greater range, more precise delivery, and rheostatic effects from “non-lethal” to “lethal”.

The NRC and CFR reports also identified two overarching issues for “non-lethal” weapons development; the lack of broad institutional support for these weapons in the Department of Defense (DOD) as a whole and the lack of funding for the JNLWP, in particular for research and development. They argued that increased funding would need to be made available for the development of new technologies and assessment of the human effects and effectiveness if new “non-lethal” weapons were to be successfully fielded. Notably, this increased support, both financial and institutional, has not been forthcoming.

Since the late 1990’s the US military has fielded a range of “non-lethal” weapons that are primarily low technology. The only new technologies that have emerged, being fielded in the past two to three years, are the Long Range Acoustic Device, which is not classified as a weapon, and various low energy “dazzling” laser weapons. Other fielded weapons, such as the Taser M26 and X26, and the FN 303, are improvements on existing technologies (electrical and kinetic/delivery), rather than dramatically new systems. Noticeably all these weapons have emerged from the private sector. In fact it is conspicuous that few new weapons have emerged from military research and development programmes.

Furthermore, from an operational perspective, the rhetoric of the revolutionary potential of “non-lethal” weapons has not been realised in practice. In Iraq, the type of urban combat put forward as the ideal for “non-lethal” weapons deployment, their use thus far has been very limited outside prison camps. Whether this is due to the pervading limitations of existing low technology

“non-lethal” weapons or broader limitations on the practicality or military willingness to substitute “non-lethal” for “lethal” force remains to be seen.

In terms of overcoming technical limitations in the future, the JNLWP is putting its hope firmly in directed energy weapons. The first new directed energy weapon aside from low energy “dazzling” lasers, the millimetre wave Active Denial System, may be fielded in the next few years. A number of other research and development efforts are focusing on high energy lasers and radiofrequency systems, in particular elucidating biological effects. This move towards “effects-based” design applies to all “non-lethal” weapons technologies. In recent years, perhaps because of the popularity of the Long Range Acoustic Device amongst military services, acoustic weapons concepts have also been revisited and some research and development is continuing.

Another focus is on new delivery systems, in part to extend the range of existing technologies such as electrical weapons, but a particular focus is the development of mid and long range airburst munitions. The key issue here is what they will contain. All signs point towards some form of chemical agent and the most attractive from a military operational perspective may be incapacitating agents, which offer the potential for far more profound (e.g. “extended duration”) effects than irritant, malodorant, or slippery chemicals. Of course the Chemical Weapons Convention (CWC) limits the use of riot control agents (irritant chemical agents and perhaps malodorants as well) to “law enforcement including domestic riot control” and even the most unrestrictive interpretations would also limit the use of biochemical incapacitating agents to these circumstances. The Biological Weapons Convention has no exemption for law enforcement purposes. Nevertheless military interest appears to persist and the political inertia, in terms of addressing the issue, has not been broken.

In terms of technology development the National Institute of Justice programme is peripheral, with a smaller scope and lower funding. In the main, research continues on assessing the safety limitations and extending the effectiveness of existing technologies, where the main priorities include increasing range and providing multiple shot capabilities. However, NIJ maintains close connections with the DOD and is co-sponsoring research in various directed energy weapons programmes. It has also funded research on incapacitating agents, offering the DOD a potential mechanism to circumvent legal restrictions. However, it is in domestic policing rather than military operations that “non-lethal” weapons continue to be used most widely. It may be that emerging weapon systems follow this pattern.

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<sup>1</sup> Quotation marks are used in recognition of enduring concerns over use of the term ‘non-lethal’ or other terms related to lethality (such as ‘less-lethal’) when applied to a weapon or group of weapons.

<sup>2</sup> This paper covers 2000 to 2006 inclusive although some more recent sources are included.

<sup>3</sup> Davison, N. (2006) *The Early History of “Non-Lethal” Weapons*. Occasional Paper No. 1. Bradford: University of Bradford, Department of Peace Studies, Bradford Non-Lethal Weapons Research Project.

<sup>4</sup> Davison, N. (2007) *The Development of “Non-Lethal” Weapons During the 1990’s*. Occasional Paper No. 2. Bradford: University of Bradford, Department of Peace Studies, Bradford Non-Lethal Weapons Research Project.

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- <sup>5</sup> National Institute of Justice (2001) *National Institute of Justice 2000 Annual Report to Congress*. Washington, DC: Department of Justice, National Institute of Justice, p. 10.
- <sup>6</sup> Office of Justice Programs (2001) *A Resource Guide to Law Enforcement, Corrections, and Forensic Technologies*. Washington, DC: Department of Justice, Office of Justice Programs and Office of Community Oriented Policing Services, p. 12.
- <sup>7</sup> Less-Than-Lethal Technology Support, Grant Number: 2001-RD-CX-K002. *NIJ Research Portfolio*. December 2006 at: <http://nij.ncjrs.org/portfolio/> [Note, March 2007: This resource is no longer publicly available, it now appears to be password protected.]
- <sup>8</sup> Kenny, J., Heal, S., and Grossman, M. (2001) *The Attribute-Based Evaluation (ABE) of Less-Than-Lethal, Extended-Range, Impact Munitions*. State College, PA: Pennsylvania State University, The Applied Research Laboratory.
- <sup>9</sup> Cecconi, J. (2003) Less-Than-Lethal Program. *Presentation to the 2003 National Institute of Justice Annual Technology Conference*.
- <sup>10</sup> Institute of Non-Lethal Defense Technologies (INLDT) E-Forum. Available March 2007 at: <http://nldt2.arl.psu.edu/>
- <sup>11</sup> National Institute of Justice (2003) *National Institute of Justice 2002 Annual Report*. Washington, DC: Department of Justice, National Institute of Justice, p. 5-6.
- <sup>12</sup> Aviation and Transportation Security Act, Public Law 107-71, 19 November, 2001, Section 126 (a).
- <sup>13</sup> Hart, S. (2002) *Statement before The Subcommittee on Aviation, Committee on Transportation and Infrastructure, U.S. House of Representatives*. Washington, DC: US House of Representatives.
- <sup>14</sup> *Ibid*.
- <sup>15</sup> Fenton, G. (2001) *Presentation for Airline Pilot Association, October 2001*. Quantico, VA: Joint Non-Lethal Weapons Directorate. Obtained under FOIA by The Sunshine Project and available March 2007 at: <http://www.sunshine-project.org/incapacitants/jnlwdpdf/jnlwdnarcoair.pdf>
- <sup>16</sup> Hart, S. (2002) *Statement before The Subcommittee on Aviation, Committee on Transportation and Infrastructure, U.S. House of Representatives*. Washington, DC: US House of Representatives.
- <sup>17</sup> National Commission on Terrorist Attacks (2004) *The 9/11 Commission Report: Final Report of the National Commission on Terrorist Attacks Upon the United States*, pp. 5-7.
- <sup>18</sup> US Government Accountability Office (2006) *Aviation Security: Further Study of Safety and Effectiveness and Better Management Controls Needed If Air Carriers Resume Interest in Deploying Less-than-Lethal Weapons*, GAO-06-475. Washington, DC: Government Accountability Office (GAO).
- <sup>19</sup> Hart, S. (2002) *Statement before The Subcommittee on Aviation, Committee on Transportation and Infrastructure, U.S. House of Representatives*. Washington, DC: US House of Representatives.
- <sup>20</sup> DePersia, T. and Cecconi, J. (2001) Less-Than-Lethal Program. *Presentation to the Non-lethal Technology and Academic Research Symposium (NTAR) III, Portsmouth, NH, 7-9 November 2001*
- <sup>21</sup> Dennis, R., Hamson, J., Mitchell, W., Apsey, D., Cora, S., and Williams, J. (2001) *Visual Effects Assessment of the Green Laser-Baton Illuminator (GLBI) (Revised Edition)*. AFRL-HE-BR-TR-2001-0095. Brooks AFB, TX: Air Force Research Laboratory, Human Effectiveness Directorate, Directed Energy Bioeffects Division, Optical Radiation Branch.
- <sup>22</sup> The table acknowledges that riot control agents (RCAs) are not restricted for use by law enforcement agencies. Therefore the assessment in the table under 'Law Enforcement' that use of chemicals is viewed as 'restrictive' must refer to incapacitating agents (so called "calmatives") of the type under investigation by Pennsylvania State University for the NIJ at the time.
- <sup>23</sup> Boyd, D. (2000) The Search for Low Hanging Fruit: Recent Developments in Non-Lethal Technologies. In: Dando, M. (ed.) *Non-Lethal Weapons: Technological and Operational Prospects*. Coudsdon: Jane's.
- <sup>24</sup> DePersia, T. and Cecconi, J. (2001) Less-Than-Lethal Program. *Presentation to the Non-lethal Technology and Academic Research Symposium (NTAR) III, Portsmouth, NH, 7-9 November 2001*.
- <sup>25</sup> National Institute of Justice (2002) *NIJ Less-Than-Lethal Technology Solicitation, FY 2002*. Washington, DC: Department of Justice, National Institute of Justice.
- <sup>26</sup> Cecconi, J. (2002) Less Than Lethal Program. *Presentation to the National Defense Industrial Association (NDIA) conference, Non-Lethal Defense V: Non-Lethal Weapons: Now, More Than Ever, 26-28 March 2002*.
- <sup>27</sup> E-LABS, Inc. (2003) *Performance Characterization Study: Noise Flash Diversionary Devices (NFDDs), Final Report*. (National Institute of Justice contract 2002-DT-CS-K001.) Washington, DC: Department of Justice, National Institute of Justice.



<sup>28</sup> Project entitled *Analysis of Airport Security Measures and the Role of Less-Lethal Weapons* conducted by National Security Research Inc. from 1 December 2002 to 31 August 2004. Details available March 2007 at: <http://www.ojp.usdoj.gov/nij/topics/lesslethal/projects.htm>; Truesdell, A. (2004) *Airport Security Measures and the Role of Less-Lethal Technologies. Presentation to the 2004 National Institute of Justice Annual Technology Conference.*

<sup>29</sup> Sandia National Laboratories, Law Enforcement Technologies, Inc., and Martin Electronics, Inc. (2002) *Final Report to the National Institute of Justice on Grant Number 2000LTBXK004, Variable Range Less-Than-Lethal Ballistic.* Washington, DC: Department of Justice, National Institute of Justice; Lewis, B. (2003) *NIJ's Less-Than-Lethal Flash-Bang Round Project. Corrections Today*, Vol. 65, No. 5.

<sup>30</sup> This was following a solicitation issued in February 2003: National Institute of Justice (2003) *NIJ Science and Technology Solicitation FY 2003.* Washington, DC: Department of Justice, National Institute of Justice.

<sup>31</sup> National Institutes of Justice (2004) *Solicitation. Less-Lethal Technologies, Fiscal Year 2004.* Washington, DC: Department of Justice, National Institute of Justice, p. 2.

<sup>32</sup> National Institute of Justice (2005) *NIJ Awards in Fiscal Year 2004.* Washington, DC: Department of Justice, National Institute of Justice.

<sup>33</sup> National Institute of Justice (2005) *2004 Annual Report to Congress.* Washington, DC: Department of Justice, National Institute of Justice, p. 51; Hambling, D. (2005) Police toy with 'less lethal' weapons. *New Scientist*, 2 May 2005.

<sup>34</sup> US Marine Corps (2004) Award: A -- Technology Investment Program Non-lethal Weapons Study (Ref: M67854-04-R-6007). *FBO Daily*, 3 July 2004.

<sup>35</sup> Hambling, D. (2005) Police toy with 'less lethal' weapons. *New Scientist*, 2 May 2005.

<sup>36</sup> Air Force Research Laboratory (2005) *AFRL Builds Portable Laser Weapon.* DE-S-06-01. Wright-Patterson AFB, OH: Air Force Research Laboratory.

<sup>37</sup> Hambling, D. (2005) Police toy with 'less lethal' weapons. *New Scientist*, 2 May 2005; Knight, W. (2005) US military sets laser PHASRs to stun. *New Scientist*, 7 November 2005; Air Force Research Laboratory (2005) *AFRL Builds Portable Laser Weapon.* DE-S-06-01. Wright-Patterson AFB, OH: Air Force Research Laboratory.

<sup>38</sup> National Institute of Justice (2005) *2004 Annual Report to Congress.* Washington, DC: Department of Justice, National Institute of Justice, p. 51

<sup>39</sup> Only anti-personnel related funding is included in the table. Funding for anti-vehicle weapons is excluded except where it is part of contracts addressing the overall programme. Data are taken from: National Institute of Justice (2001) *NIJ Awards in Fiscal Year 2000.* Washington, DC: Department of Justice, National Institute of Justice; National Institute of Justice (2002) *NIJ Awards in Fiscal Year 2001.* Washington, DC: Department of Justice, National Institute of Justice; National Institute of Justice (2003) *NIJ Awards in Fiscal Year 2002.* Washington, DC: Department of Justice, National Institute of Justice; National Institute of Justice (2004) *NIJ Awards in Fiscal Year 2003.* Washington, DC: Department of Justice, National Institute of Justice; National Institute of Justice (2005) *NIJ Awards in Fiscal Year 2004.* Washington, DC: Department of Justice, National Institute of Justice; National Institute of Justice (2006) *NIJ Awards in Fiscal Year 2005.* Washington, DC: Department of Justice, National Institute of Justice; National Institute of Justice (2007) *NIJ Awards in Fiscal Year 2006.* Washington, DC: Department of Justice, National Institute of Justice.

<sup>40</sup> Further description from *NIJ Research Portfolio*, available December 2006 at: <http://nij.ncjrs.org/portfolio/> [Note, March 2007: This resource is no longer publicly available, it now appears to be password protected.]: "National Security Research, Inc. (NSR) will provide the National Institute of Justice with a reference guide of the Department of Defense Joint Non-Lethal Weapons Program. This guide will focus on commercial-off-the-shelf (COTS) and unclassified science and technology development equipment items from both military and civil law enforcement. The reference guide will be a valuable tool for state and local law enforcement and corrections agencies to use to understand DOD research and development of less-than lethal technology and specific equipment."

<sup>41</sup> Further description from *NIJ Research Portfolio*, available December 2006 at: <http://nij.ncjrs.org/portfolio/> [Note, March 2007: This resource is no longer publicly available, it now appears to be password protected.]: "Pennsylvania State University - Applied Research Laboratory (ARL) will explore the potential of employing non-toxic agents that will deter, dissuade, or better control crowd activity. This research will be conducted in three phases. Phase One will establish test protocols for Attribute-Based Evaluations of Less-Than-Lethal (LTL) munitions; Phase Two will

conduct an investigation of controlled exposure to caltivate-based oleoresin capsicum. Phase Three will provide an E-Forum to support an operational needs assessment for less-than-lethal technologies.”

<sup>42</sup> Further description from *NIJ Research Portfolio*, available December 2006 at:

<http://nij.ncjrs.org/portfolio/> [Note, March 2007: This resource is no longer publicly available, it now appears to be password protected.]: “The goal of this project is to use existing information within the injury risk arena to develop a computer model to assess the risk of injury of non-lethal kinetic energy rounds. This is an area in which the non-lethal community has limited information, and work to produce models to predict risk assessment. This is an important first step for future developments and the next logical step in the process. This project will likely require follow-on efforts to get to a final product: a working computer model, which can simulate the human thorax as well as the projectile.”

<sup>43</sup> Further description from *NIJ Research Portfolio*, available December 2006 at:

<http://nij.ncjrs.org/portfolio/> [Note, March 2007: This resource is no longer publicly available, it now appears to be password protected.]: “The award will evaluate the Multi-sensory Grenade (MSG), developed by the DoD Joint Non-Lethal Weapons Directorate, for law enforcement applications. Field evaluations will be performed by one or more law enforcement or correction agencies. Information obtained from the evaluations will be used to evaluate the adequacy of these devices for civilian use and to define the device's specifications that will enable the device to be used by civilian agencies. The MSG combines intense audible acoustics, intense pulsed light, and other field-selectable LTL effects (malodorants, sting balls, CS, etc.) in a grenade designed to control the movement of individuals and crowds.”

<sup>44</sup> Further description from *NIJ Research Portfolio*, available December 2006 at:

<http://nij.ncjrs.org/portfolio/> [Note, March 2007: This resource is no longer publicly available, it now appears to be password protected.]: “Vanek Prototype Co. will design, fabricate, test, and demonstrate an eight-shot ring airfoil projectile (RAP) launcher that can deliver blunt impact projectiles with a future payload to a maximum range of 50 meters. The projectile is less-than-lethal at the muzzle and is eye safe. The single shot RAP developed in the previous program has shown to be practical, but that a multi-shot system is needed. The Multi-Shot RAP can be used in civilian LTL scenarios by corrections, law enforcement agencies, and the FAA/TSA.”

<sup>45</sup> Further description from *NIJ Research Portfolio*, available December 2006 at:

<http://nij.ncjrs.org/portfolio/> [Note, March 2007: This resource is no longer publicly available, it now appears to be password protected.]: “This project will evaluate LTL technology for risk of penetration associated with kinetic energy munitions. Wayne State will evaluate existing LTL technology and expand testing beyond current models that involve gelatin as a tissue simulant by identifying a more realistic skin simulant for testing. The evaluation will identify risks related to LTL kinetic energy munitions and will provide results that correctional and law enforcement agencies can use in determining appropriate uses and associated safety of LTL weapons.”

<sup>46</sup> Further description from *NIJ Research Portfolio*, available December 2006 at:

<http://nij.ncjrs.org/portfolio/> [Note, March 2007: This resource is no longer publicly available, it now appears to be password protected.]: “This is the second phase of a project to demonstrate the ability to precisely deliver and activate a flash-bang device at ranges of 20 to 100 meters. This would provide law enforcement and corrections officers the capability to deter, distract, or dissuade individuals or a crowd from a safer distance than presently is possible with less possibility of injuries.”

<sup>47</sup> Further description from *NIJ Research Portfolio*, available December 2006 at:

<http://nij.ncjrs.org/portfolio/> [Note, March 2007: This resource is no longer publicly available, it now appears to be password protected.]: “This proposal will provide a biomechanical assessment of blunt ballistic impacts to the abdomen by: 1) Developing human response corridors to such impacts by using data derived from specimens; and 2) Validating an appropriate injury criterion for use in determining the risk of injury related to these impacts. A stiff baton weighing 30 grams will be launched at 60 m/s into specimens to a spot directly over the abdomen. Similar testing will be completed on animal specimens. The combination of these data will be used to formulate the injury criterion for the abdomen.” In the original contract from 2005 the title was: “Evaluation of Standard Development for Kinetic Energy Impact Munitions”

<sup>48</sup> Further description from *NIJ Research Portfolio*, available December 2006 at:

<http://nij.ncjrs.org/portfolio/> [Note, March 2007: This resource is no longer publicly available, it now appears to be password protected.]: “This proposal seeks to analyze current security measures in airports and ways to improve security by introducing less-than-lethal weapons. The results of the analysis can be used by FAA/TSA, law enforcement and possibly correctional departments. The report

will provide information related to policies on the use of force in the airport and the application of less-than-lethal technology in force-related situations at airports.”

<sup>49</sup> National Institutes of Justice (2004) *Solicitation. Less-Lethal Technologies, Fiscal Year 2004*, SL 000638. Washington, DC: Department of Justice, National Institute of Justice, p. 2.

<sup>50</sup> Project entitled *Model Electric Current Through the Human Body From Less-lethal EMDT Devices*, running from 1 August 2004 to 1 July 2007. Further details available March 2007 at: <http://www.ojp.usdoj.gov/nij/topics/lesslethal/projects.htm> - “Researchers will attempt to model the flow of current through a human body as delivered by less-lethal EMDT devices and experimentally validate the results. From this information, researchers will attempt to determine safety margins related to potential cardiac fibrillation.”

<sup>51</sup> Project entitled *Injuries Produced by Law Enforcement Use of Less-lethal Weapons: A Prospective Multicenter Trial*, running from 1 November 2004 to 31 October 2007. Further details available March 2007 at: <http://www.ojp.usdoj.gov/nij/topics/lesslethal/projects.htm> - “Researchers will collect data on the proportion of suspects who sustain injuries after less-lethal weapons (both EMDT and kinetic impact weapons) are used during their apprehension by law enforcement officers and on the severity of those injuries. The data will be collected from 12 law enforcement agencies and reviewed by physicians with extensive experience in law enforcement operations.”

<sup>52</sup> National Institute of Justice (2005) *NIJ Awards in Fiscal Year 2004*. Washington, DC: Department of Justice, National Institute of Justice; National Institute of Justice (2006) *NIJ Awards in Fiscal Year 2005*. Washington, DC: Department of Justice, National Institute of Justice.

<sup>53</sup> Projects entitled *Verifying Reported Effectiveness of EMDT Devices in Reducing Deaths and Injuries and Review of Less-lethal Technology Operational Needs*, running from 1 September 2004 to 31 October 2008. Further details available March 2007 at:

<http://www.ojp.usdoj.gov/nij/topics/lesslethal/projects.htm> - “Researchers will use existing Los Angeles Sheriff’s Department data on EMDT device use to derive independently statistics on the effectiveness of EMDTs. Factors defining effectiveness will include the reduction in the number of deaths and injuries sustained by officers, suspects, and bystanders from the use of less-lethal EMDT devices versus firearms. Researchers also will collect expert advice on the operational scenarios that are appropriate for the use of less-lethal weapons.”

<sup>54</sup> Mazzara, A. (2005) *Less-Lethal Technologies: Today and Tomorrow. Presentation to the Technologies for Public Safety in Critical Incident Response Conference and Exhibition 2005, 31 October – 2 November 2005, Marriott Hotel and Marina, San Diego, California.*

<sup>55</sup> National Institute of Justice (2004) *Solicitation for Concept Papers. Less-Lethal and Pursuit Management Technologies*, SL 000689. Washington, DC: Department of Justice, National Institute of Justice, p. 2.

<sup>56</sup> National Institute of Justice (2005) *Solicitation for Concept Papers. Outcomes of Police Use of Force*, SL 000695. Washington, DC: Department of Justice, National Institute of Justice, pp. 1-2.

<sup>57</sup> Further details available March 2007 at: <http://www.ojp.usdoj.gov/nij/topics/lesslethal/projects.htm>.

<sup>58</sup> National Institute of Justice (2005) *Solicitation for Concept Papers: Less Lethal Technologies*, SL 000728. Washington, DC: Department of Justice, National Institute of Justice; At the time of writing the NIJ released another solicitation: National Institute of Justice (2006) *Solicitation: Less Lethal Technologies*, SL 000754. Washington, DC: Department of Justice, National Institute of Justice.

<sup>59</sup> National Institute of Justice (2005) *Solicitation for Concept Papers: School Safety Technologies*, SL 000718. Washington, DC: Department of Justice, National Institute of Justice.

<sup>60</sup> However, it is conceivable that classified projects on new weapons technologies were funded.

<sup>61</sup> Further details available March 2007 at:

[http://www.ojp.usdoj.gov/nij/topics/lesslethal/emdt\\_study.htm](http://www.ojp.usdoj.gov/nij/topics/lesslethal/emdt_study.htm)

<sup>62</sup> Air Force Research Laboratory (2005) *AFRL Builds Portable Laser Weapon*. DE-S-06-01. Wright-Patterson AFB, OH: Air Force Research Laboratory.

<sup>63</sup> Hart, S. (2002) *Statement before The Subcommittee on Aviation, Committee on Transportation and Infrastructure, U.S. House of Representatives*. Washington, DC: US House of Representatives; This figure is for all “non-lethal” weapons funding and includes anti-vehicle weapons. The figure excluding specifically anti-vehicle projects for 2000-2006 is an average of just under \$1.4 million per year, calculated from the funding contracts listed in Table 2.

<sup>64</sup> National Research Council (2003) *An Assessment of Non-Lethal Weapons Science and Technology*. Washington, DC: National Academies Press, p. 69.

<sup>65</sup> Homeland Security Advanced Research Projects Agency (2005) *Innovative Less-Lethal Devices for Law Enforcement Technology Areas: State and Local*. HSARPA SBIR FY-05.1, Topic H-

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