Home Office

Scientific Development Branch

Less Lethal Technologies

Review of Commercially Available and Near-Market Products for the Association of Chief Police Officers

Publication No. 49/08

M Symons
G Smith
G Dean
S Croft
C O'Brien

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Home Office Scientific Development Branch
Sandridge
St Albans
AL4 9HQ
United Kingdom

Telephone: +44 (0)1727 865051
Fax: +44 (0)1727 816233
E-mail: hosdb@homeoffice.gsi.gov.uk
Website: http://science.homeoffice.gov.uk/hosdb/

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1 Management Summary

Managing conflict safely and effectively depends on an ability to deploy a range of appropriate tactical options. The Home Office Scientific Development Branch (HOSDB) has been working closely with the relevant ACPO committees and UK government agencies over the past eight years to assist in the coordinated UK effort to introduce less lethal options to the UK Police Service. This helps ensure that the Police Service has the ability to best protect the lives and rights of all involved with policing incidents by the appropriate use of force (officers, subjects and the public in general).

This report forms part of HOSDB's ongoing work into less lethal options and provides the reader with a review of commercially available and near market less lethal options against the context of the Association of Chief Police Officers (ACPO) Operational Requirement for Less Lethal Options.

This review has shown that there has been limited commercial advances in many areas of less lethal technologies since the previous review by HOSDB in 2001, and that the UK Police Service is equipped with the most suitable and effective less lethal options currently available.

A number of technological advances have occurred in the area of directed energy weapons. Although currently available commercial devices are not suited for policing applications in the UK, or approved for use, these devices could in the future provide a capability for the UK Police to engage subjects at a greater range and with more precision than is currently achievable.

2 Introduction

This report covers a review by the Home Office Scientific Development Branch (HOSDB) into commercially available and near-market less lethal technologies. It is intended to inform the reader of the types of weaponry and systems that are available at present and provide guidance on aspects of performance and suitability against the reaffirmed ACPO Operational Requirement for less lethal options[1] (included as Appendix A).

This report follows on from the previous review by HOSDB of commercially available and near market less lethal technologies conducted in 2001[2].

Information in this report relating to effectiveness of technologies and devices was obtained from many different sources including previous UK governmental work into less lethal options, governmental work conducted internationally and manufacturers' literature. It is important to note that this report does not provide a detailed assessment of any less lethal devices and further work would be required if any devices not already approved for use are to be deployed in policing applications.

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[1] Association of Chief Police Officers Conflict Management "Less Lethal Options – An Operational Requirement" 2008

[2] Less Lethal Technologies, An Interim Review of Commercially Available and Near-Market Products, PSDB, 2/01 GSmith et al.

3 Technologies Available

It is important to note that the term "Less Lethal" is carefully defined to encompass weapons and equipment which, although less likely than firearms to result in a serious or fatal injury, nevertheless carry some degree of risk.

The ACPO definition for less lethal options has been agreed as:

> *The term 'less lethal options' is employed to include weapons, devices or tactics whose design and intention is to control and then neutralise a threat without substantial risk of serious or permanent injury or death. While the actual outcome may occasionally be lethal, this is less likely than the result of the use of firearms, for example.*

Many different types of devices or technologies could be used to produce the effects required from less lethal options. These required effects range from incapacitation to simple dissuasion from entering an area. The technologies can be broadly divided into the following categories:

- Kinetic Energy Devices
- Electrical Devices
- Directed Energy Devices
- Water Cannon
- Chemical Delivery Devices
- Long Range Hailing Devices
- Pyrotechnic Devices

Each category is expanded in the following sections and accompanied by a brief generic summary of varieties of options and likely performance against key aspects of the ACPO Operational Requirement. Information contained in this document that relates to the performance of devices has been obtained from previous governmental work into less lethal options (when available), from international contacts and from manufacturers. Not all information has been verified by HOSDB and as such should be used for indication purposes only. Before using any data please refer back to HOSDB to verify its status.

It should also be noted that the effectiveness and injury potential of any less lethal option is governed largely by the guidelines for use.

4 Kinetic Energy Devices

Impact devices are designed to deliver an impact which is not intended to cause serious or life threatening injury, but is of sufficient force to dissuade or prevent a potentially violent person from their intended course of action and therefore neutralise the threat.

There are a large number of kinetic energy (KE) devices available from a number of international manufacturers. These are available in standard 37mm, 40mm and 12 gauge calibres as well as a number of rounds with a different calibre, which tend to have their own specific launcher. Many are also available for use at different distances, for example for close, medium and long range use. Some manufacturers make a wide range of impact rounds in a range of calibres, energy levels and classes of munitions while others may only make one or two. Costs of rounds vary greatly and range from around £2 per round to over £25 per round. A list of kinetic energy device manufacturers is shown in Appendix B, this list is as complete as the timescales of this project allowed but may not be comprehensive.

The performance of these rounds, including their accuracy and range, varies dramatically depending on the composition of the round, the weapon system from which they are fired, the sighting system used to acquire the target, the guidance and training received by users, and the quality of the manufacturing process. Often manufacturers' data cannot be relied on to provide an accurate assessment of the rounds' capabilities in operational conditions.

Impact rounds have a complex balance between effectiveness and unintended consequences. Many rounds may be safe and effective when they strike one part of the body, but may cause serious injury or even death if they strike a vulnerable area of the body. Hence accuracy is one of the more important attributes of these types of round if unintended injuries are to be minimised.

Injuries from impact rounds are classed as perforating or non-perforating. Plainly, less lethal equipment relying on kinetic energy for effectiveness should not perforate the body wall. In general, a reduction in contact area between the round and target will increase the probability of perforation. Serious injury may still be caused to internal organs and structures by a non-perforating impact, indeed, this is the most common form of trauma injury observed in UK hospitals. The most vulnerable areas in terms of potential for serious or life threatening injury are:

head – facial skeleton, brain, eyes:

thorax – rib fractures, lung contusion/laceration, heart injury and associated electrical disturbances

abdomen – the liver is vulnerable to some forms of non-penetrating impact. Although not strictly a thoracic organ, it is overlaid by the rib cage. Damage to the liver may result in serious internal haemorrhage.

Secondary injuries may also be sustained if the impact from the KE device causes the subject to fall. In policing environments specific risks include subjects falling from height onto hard surfaces. Clearly, this could result in severe injury or even death to subjects.

Countermeasures against impact devices include any materials that can be used to attenuate the energy from an impact sufficiently for the impact not to deter the target. Examples range from professional sporting or policing protective equipment, such as body armour, chest protectors, riot helmets, life jackets, motorcycle helmets, limb protectors etc. to improvised solutions such as heavy clothing, foam padding, dustbin lids etc.

*Figure 1: **H&K L104A1 37mm Launcher (Single Shot)***

*Figure 2: **Penn Arms PGL TAC40 40mm Launcher (Multi Shot)***

Deployment timing for impact rounds is largely dependant on the weapon or launcher used to fire the round. Launchers can broadly be divided into two categories, single shot and multi shot. Single shot launchers require reloading in between each shot fired, which involves opening the weapon, removing the cartridge of the previous round, chambering the next round and cocking the weapon. An example of a single shot launcher is shown in Figure 1. This process can be completed in well under 10 seconds by an accomplished gunner for this weapon. Multi shot launchers have the ability of firing multiple shots without reloading, these vary in capacity from two rounds up to six or more rounds. The time between firing shots can be reduced with multi shot launchers to under 1 second. However the time taken to load the multi-shot weapon is longer than that for a single shot weapon. Multi-shot weapons also tend to be larger and heavier than single shot launchers. An example of a multi shot launcher is shown in Figure 2. Launchers can be further categorised into rifled and smooth bore versions, rifled versions tending to be far more accurate than smooth bore versions as they can impart a stabilising rotational spin on the round.

The following section outlines the different classes of impact rounds commercially available and highlights likely performance characteristics against key aspects of the ACPO Operational Requirement. Pictures are chosen to be representative of the class of round and are not intended to indicate a preference.

4.1 Bean Bag

The bean bag consists of a square or circular envelope of fabric containing lead shot and is generally fired from a 12 gauge weapon although it is also available in larger calibres including 37mm and 40mm. Rounds are also available containing more than one bean bag. The round is intended to hit one person and to flatten on impact, hitting face on, and spreading its energy over a large area. Manufacturers' data indicates this type of round typically has a range of 5–30m depending on model type. There are currently over 20 models of bean bag commercially available from six different manufacturers. A selection of commercially available bean bags is shown in Figure 3.

Figure 3: ***Three commercially available bean bags***

Previous testing at HOSDB has shown that many of these rounds are unable to meet basic police accuracy requirements. The rounds also have a tendency to hit subjects edge–on or still folded. This leads to a much higher energy density (energy per unit area) at the target than the intended presentation, i.e. the bag striking face on with the largest surface hitting the target. This variation in impact energy affects both the operational performance of the round and the degree of risk to which a person is exposed; indeed a number of bone fractures have been reported as well as deaths in the US associated with the perforation of bean bags into the body.

4.2 Sock Round

These rounds were developed because of the aforementioned problems with the bean-bag rounds. The rounds contain lead shot in a fabric 'sock' typically 40mm in length with a longer tail to aid stabilisation in flight. The tail helps ensure that the orientation of the rounds stays consistent in flight and upon hitting the target. Many variations on this design are available and are generally fired from a 12 gauge weapon. Range is 5–30m depending on model type. A selection of commercially available sock rounds is shown in Figure 4.

Figure 4: ***Three commercially available sock rounds***

Following testing by HOSDB and the Defence Scientific Technology Laboratory (Dstl), ACPO concluded that the best performing 12Ga sock round did not meet their Operational Requirement for an alternative to conventional firearms. It had few benefits and many disadvantages over the deployed alternative at the time, the L21A1 baton round. Disadvantages included increased incidence of body wall perforation and reduced effectiveness[3].

[3] Patten Report Recommendations 69 and 70 relating to Public Order Equipment, Phase 4 report, UK Steering Group January 2004

4.3 Fin Stabilised Rubber Projectile

*Figure 5**: Three commercially available fin stabilised rubber projectiles***

Fin stabilised rubber rounds are fired from a 12 gauge shotgun or compressed gas weapon. Ranges are quoted by manufacturers to be up to 45m. The fins are added to the projectile to increase stability and hence improve accuracy at longer range. A selection of commercially available fin stabilised rubber projectiles are shown in Figure 5.

A number of products of this class have been tested previously by HOSDB. The performance of these rounds varied considerably between individual products, but a number met the basic police requirements for accuracy at 20m. Due to the small calibre of these devices and the increased risk of eye penetration and body wall perforation, in-depth tests have not been conducted on these devices.

4.4 Multi-Ball Rounds

A number of different rounds are available that deliver multiple rubber balls. Most are designed to be fired from a standard 12 gauge shotgun but other calibres may also be found. These rounds are relatively indiscriminate and have ranges dependent on a number of factors including diameter of balls, number of balls, calibre of round and amount of propellant. At close range, before the shot pattern has spread, they may impart a considerable amount of energy over a small area. However, the shot spreads rapidly and loses its energy quickly due to the low mass of the balls, particularly the smaller sizes. An example of a commercially available multi-ball round is shown in Figure 6.

*Figure 6**: Commercially available multi-ball round***

Previous testing at HOSDB has shown that rounds in this class spread quite considerably when fired and are very inaccurate, as such, their effective range is limited. This is an inherent property of this class of round as they are designed to spread their impact over a larger area and may even be used to target a number of people at one time. In-depth tests have not been conducted on these devices to date due to their indiscriminate nature and the increased risk of eye penetration and body wall perforation

4.5 Baton Rounds (Commercially available)

These rounds are available from commercial companies and are distinct from the impact rounds used by the police which are described in the next sub-section.

There are a large number of different types of baton round available which are made from various materials, including wood, rubber, foam and plastics. Many devices in this class have previously been tested by HOSDB and were found not to meet basic police accuracy requirements. Many failed due to the inability to be fired from a rifled launcher. The most promising devices in this class claim to have an effective range up to 30m. An example of two commercially available foam baton rounds are shown in Figure 7.

Figure 7: ***Two commercially available foam baton rounds***

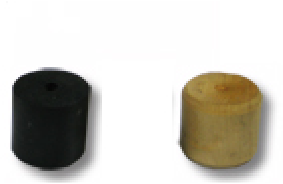

Figure 8: ***Two commercially available multi baton rounds***

Multiple rounds are also available which deploy a number of projectiles (generally three or five) at the same time. These rounds are normally fired from 37mm or 40mm weapons. Claimed ranges vary but are up to 100m. These rounds are particularly inaccurate and are not designed to be aimed at an individual. Skip-firing, or bouncing the round(s) off the ground in front of the crowd, is the recommended deployment of most rounds by the manufacturer. This makes the rounds trajectory unpredictable and hence they could easily strike vulnerable areas of the body. An example of two commercially available multi baton rounds is shown in Figure 8.

4.6 Impact Rounds (used by UK police and military)

Impact rounds used by the police have evolved steadily since their first use in Northern Ireland in 1973. Initially these rounds were made of rubber but this was found to be inaccurate and they were completely replaced by plastic rounds in 1975. These rounds have gone through various redesigns over the years, generally to improve accuracy and safety. Since 1994 an improved rifled single shot launcher (the L104A1) has also been in use.

Figure 9: ***L21A1 Baton Round***

*Figure 10: **Attenuating Energy Projectile (AEP)***

The current round is called the Attenuating Energy Projectile (AEP) and designated as the L60A1 (model L60 revision 1). This round was developed jointly by the Home Office, Northern Ireland Office and Ministry of Defence as a safer replacement for the L21A1 round[4] (see Figure 9). The round features a void in the nose that is designed to collapse upon impact with a vulnerable area of the body thus reducing the probability of serious or life threatening injury. The AEP should be aimed to strike directly (i.e. without bouncing or skip firing) the lower part of the subject's body i.e. below the rib cage. Officers are trained to use the belt buckle area as the point of aim at all ranges, thus mitigating against upper body hits. The AEP is shown in Figure 10.

Prior to its introduction in June 2005, the round underwent stringent technical and medical tests, which were reviewed, together with the guidance to users and training practices, by an independent medical panel. The medical panel found that the risk of serious or life threatening injury to the head from the AEP will be less than that from the L21A1 baton round. It is important to note that the statement from the medical panel is only valid for the current system, which comprises the weapon, the sight, the munition, the zeroing instructions, maintenance and storage instructions, ACPO guidance on use and MoD rules of engagement.

Previous technical testing of the system found that it performed very consistently and exceeded the basic requirements for accuracy at 20m with groupings of 50 shots within a 100mm diameter circle. The optimum operational range for the system used by the UK Police has been set from 1m up to 30m. The projectile is however capable of being accurate beyond this range but a redesign to the current sighting/zeroing components of the system would be required.

The AEP is currently only available to UK police and military forces for use as a less lethal option to firearms and can only be used when firearms authority has been granted. The use of the AEP by UK Police was sanctioned by the Home Secretary and ministers in June of 2005. Use outside of its current application would require new authority at ministerial level.

[4] UK Less lethal Steering Group - Phase 1-5 reports 2001-2006.

5 Electrical Devices

Electrical devices include any weapons that use the effects of electricity to incapacitate the target. A number of different devices are available but their principle of operation is similar. Typically, they can be categorised into short range types (<35ft/10m) that transfer the electrical effect using wires generically termed Conducted Energy Devices (CED) and longer range wireless (100ft/30m) types which are currently under development. Stun guns have not been included in this evaluation due to their limited range (i.e. direct contact). Electrical devices are battery powered and use a low current, high voltage impulse shock for incapacitation. The electrical stimulus delivered by the device temporarily interferes with the normal electrical signals generated by the human nervous system. The typical reaction of a person exposed to an effective application of such an electrical device is loss of muscular control resulting in the subject “freezing” on the spot and falling to the ground. Incapacitation by electrical means relies on this physiological effect rather than pain alone to achieve its objective and appears to be virtually instantaneous with almost instant recovery. Extensive medical evaluations, by both independent bodies and manufacturers have been undertaken and published[5,6], particularly for the electrical devices that are currently available on the market.

A list of electrical device manufacturers is shown in Appendix C. This list is as complete as the time scales of this project allowed but may not be comprehensive.

[5] PSDB Further Evaluation of Taser Devices, Publication Number 19/05, D Wilkinson, PSDB, 2005
[6] Supplement to HOSDB Evaluations of Taser Devices, Publication Number 64/06, D Wilkinson, HOSDB, 2006

5.1 Tasers and other Conducted Energy Devices

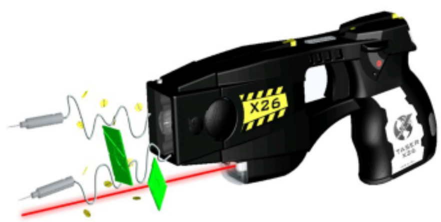

Figure 11: ***TASER® International X26***

Figure 12: ***Stinger Systems S-200***

The most widely known and commonly deployed electrical device is the TASER® manufactured by TASER® International in the United States of America. TASER® International manufactures two models for law enforcement agencies; the TASER® M26 was released in 1999 and later developed into the TASER® X26, which is shown in Figure 11. To date, devices from other manufacturers have not been available to HOSDB for evaluation although HOSDB has a standing commitment to review new commercially available devices. Figure 12 shows an example of the Stinger Systems S-200, which we hope to conduct an initial assessment of this later this year. CEDs are available to law enforcement and military agencies. 'Citizen' versions are also available to members of the public in certain countries. In the UK CEDs are classified as prohibited weapons by virtue of the Firearms Act 1968.

The principle of operation is as follows; a cartridge is attached to the front end of the weapon which contains two barbs (the electrodes) each of which is attached to a coiled length of conductive wire. In the TASER® X26 the barbs are fired and attach themselves to the skin or clothing of the targeted individual. The barbs are propelled by a small cylinder of compressed gas that is ruptured by a pyrotechnic mechanism within the cartridge. Alternative devices are known to employ conventional ballistic propulsion using a pistol primer. When barbs are attached to a person current can be sent down the wires and through the person's body between the two barbs. Each cartridge is a single shot and can only be targeted at an individual. Reloading of a new cartridge by a proficient user takes 1-2 seconds.

Cartridges are available in different versions with maximum ranges between 15ft (4.5m) and 35ft (10m). A training cartridge is also available that uses non-conductive (nylon) wires so training firing can be conducted without emitting the full electrical effect. Following evaluations of the 21ft TASER® cartridge, the cartridge used by the UK police, the optimum effective range was found to be between 5ft -15ft. The barbs exit the cartridge at a diverging angle of about 8° with the top barb travelling horizontally towards the projected red dot laser sight. At around 5ft (1.5m) the vertical separation between barbs is about 8″ (200mm) which is the minimum necessary to obtain an incapaciting effect. Above 15ft (4.5m) the top barb will drop below the indicated red laser dot and the bottom barb will hit the leg area resulting in a much lower likelihood of both barbs attaching.

Cartridge orientation is not specific when inserted into the TASER®, except in the case of the XP35 cartridge which must be inserted in the correct orientation. The XP35 is an extended range cartridge which is claimed to give a range of up to 35 feet (10.7m). To achieve this extended range the barbs must be launched at an upward trajectory. Incorrect insertion is likely to result in the barbs being fired towards the floor. This cartridge is not used in the UK.

TASER® devices are relatively simple and straightforward to use. A level of training is required to educate the user in the safety aspects and guidance for achieving a successful deployment. A trained individual can draw the TASER® from a holster with the cartridge inserted, disengage the safety switch and be ready to fire within two seconds.

To achieve a successful deployment both barbs are required to make contact with the subject. The barbs are capable of penetrating the subject's skin although the incapacitation effect may also be achieved through clothing when separated from the body by a collective distance 2" (5cm) between barbs and body.

There are a number of factors that may contribute to an unsuccessful deployment of a CED. These are summarised below:

- One of the wires failing to attach or falling out would make the device ineffective;
- Poor contact with the barbs (>2" collective distance between barbs and body);
- Flat batteries (batteries need replacing, extreme cold affecting batteries) or other electrical problems;
- Operator difficulties (missing target);
- Extremely determined individuals may maintain, though at a reduced level, a degree of motor skills e.g. still be in a position to raise/aim and fire a weapon.

Power is provided by either off-the-shelf batteries; typically eight AA type; or bespoke battery modules in the case of the TASER® X26.

Evidence from deployments has shown that the visual effect of a TASER®, generating the electrical spark or red-dotting a target with the laser sight may deter a potential target.

TASER® devices offer the capability to download firing data to a computer. Details such as time, date, duration of each firing, and battery life can be downloaded, viewed and saved in a variety of formats. In the case of the TASER® International devices 20 to 30 small discs are dispersed from the cartridge when it is fired. Printed on the discs is the unique cartridge serial number that can be used for traceability. To support the audit trial TASER® devices also have the facility to record video and audio as an optional extra.

There is considerable debate in the literature about the safety of these types of electrical devices. The principal area of concern is whether it is possible to initiate ventricular fibrillation by the use of them. Ventricular fibrillation occurs when the regular beating of the heart is interrupted during the vulnerable period of the cardiac cycle - the consequences of this are that the heart stops beating, blood pressure falls rapidly and emergency resuscitation is required. Conclusions relating to independent UK medical research[7] on TASER® International products only, determined this risk to be low. No incidences of this have been seen operationally.

Other than concerns about the effects of the Taser current on the body, there are also a number of secondary injuries which could occur. In policing environments the main concern relates to subjects falling from height onto a hard surface as a result of the electrical incapacitation, which could result in severe injury or even death.

TASER® devices are priced at between £400 to £800 and cartridges between £10 to £20. Shelf life of the TASER® cartridges has been stated at five years. The bespoke battery modules are £30 each and provide sufficient power for 300 five-second firings.

5.2 Wireless Electrical Devices

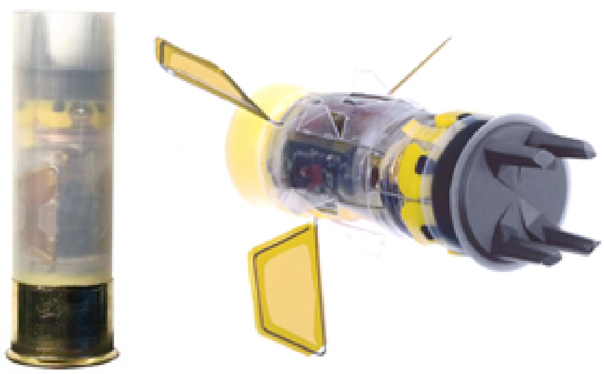

*Figure 13: **TASER® International XREP***

Developments are under way to produce a wireless electrical projectile. The objective is to deliver electrical incapacitation at a longer range. One such product being developed by TASER® International is the eXtended Range Electronic Projectile (XREP). This device fits inside a 12-gauge shotgun cartridge and incorporates similar technology to a TASER X26. The TASER® International XREP is shown in Figure 13. The XREP is fired from standard 12-gauge shotgun to claimed ranges of 100ft (30m). The projectile weighs 14g and achieves a velocity of around 300 ft/sec (100m/sec). The medical effect on human skin or tissue from the impact of such is still to be researched. No independent technical evaluations have been carried out thus far. The cost of each projectile has been estimated at approximately $100 (£50).

The manufacturer has designed XREP to produce similar effects to the TASER® X26 with on-board power to deliver a 20-second cycle.

When XREP is fired from the shotgun a rip-cord within the cartridge activates the projectile so XREP is “live” when it leaves the barrel and three sprung loaded fins are deployed to stabilise the projectile in flight. On impact, the four front barbs are designed to attach to the target and the main body of the projectile then breaks loose. The two parts remain connected by a conductive wire (approx 200mm long). As the main body swings free a series of protruding electrodes make contact with the subjects body creating a circuit

[7] Statement on the medical implications of the use of the M26 Advanced TASER®, DOMILL, December 2002 & Statement on the comparative medical implications of use of the X26 TASER® and the M26 Advanced TASER®, DOMILL, 2005

between the front barbs and main body electrodes, delivering the electrical effect. The electrical effect can also be achieved by the subject creating a circuit by grabbing any of the parts or the conductive wire with their hand.

5.3 Other Electrical Devices

Figure 14: ***TASER® Remote Area Denial (TRAD)***

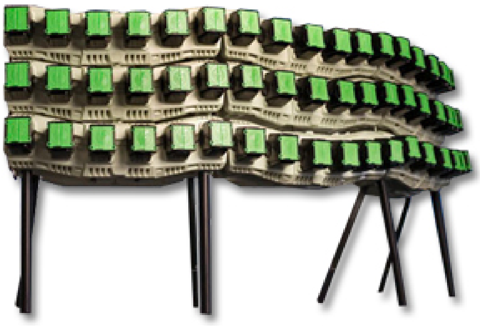

Figure 15: ***9 TASER® Shockwave units***

Electrical incapacitation and TASER® technology has been designed into a number of other products on the market. These are focused towards area denial and protecting vulnerable areas or assets. These have not been evaluated by HOSDB.

TASER® Remote Area Denial (TRAD) is marketed for military applications and can be described as having the capability to remotely deliver three applications similar to that of a TASER® X26. It can fire multiple cartridges, each independently controlled. The device incorporates sensors and can be networked to extend control functionality. A TASER® Remote Area Denial device is shown in Figure 14.

The TASER® Shockwave is also designed for area denial applications. The single unit contains six TASER® cartridges set in an arc formation that are fired simultaneously. The system is modular and multiple banks can constructed in a building block style to extend the coverage area. The company plan a full release of the product for field testing in 2008. An example of nine connected TASER®Shockwave devices is shown in Figure 15.

TASER® International have recently formed an alliance with iRobot Corp and propose plans to mount TASER® technology devices onto a robotic platform to extend the engagement range with potential assailants.

6 Directed Energy Devices

This category encompasses devices that direct energy to a target using various frequencies within the electromagnetic spectrum. Since the previous review carried out in 2001[8] some major advances have been made in this category of weapon and it is envisaged that this category will see the most development over the coming years. Many frequencies within the spectrum have been exploited and prototype and commercial equipment is available. The following sections describe the types of equipment available and give an overview of their capabilities, stage of development and physical effects. A list of directed energy device manufacturers is shown in Appendix D. This list is as complete as the time scales of this project allowed but may not be comprehensive.

6.1 High Intensity Portable Lighting

Bright lights can be considered for use as distraction or disorientation devices by virtue of the dazzle effect.

Figure 16: ***Commercially available high intensity spotlight***

High intensity portable hand-held (or vehicle mounted) spotlights have been available for some time and have been used to provide a low-level of distraction by causing temporary blindness. They do not incapacitate as such, but prevent an individual from accurately placing a shot or throwing a missile. An example of a commercially available high intensity portable spotlight is shown in Figure 16.

High intensity lighting can be used to illuminate areas up to 2 kilometres away, but the disorientation effect rapidly decreases with distance and is unlikely to be effective above 100 metres. However, with equipment of this type rated from 750,000 up to 6 million candela, there is a risk of permanent eye damage at closer ranges. Rapidly pulsed (stroboscopic) high intensity light has a disorientating effect but is indiscriminate. There are concerns that it may induce epileptic seizure, particularly at frequencies between 5 and 30Hz. The Health and Safety Executive (HSE) recommends that strobes used in public be less than 5Hz[9].

The recent developments in LED technology have seen the emergence of low cost, high intensity devices with much lower power requirements resulting in increased portability. Concerns with regard to eye safety remain together with the ease of deployment of counter-measures against this technology.

[8] Less Lethal Technologies, An Interim Review of Commercially Available and Near-Market Products, PSDB, 2/01 GSmith et al.

[9] Health and Safety Executive Local Authority Circular 51/1, Disco Lights and Flicker Sensitive Epilepsy, November 2000.

6.2 Laser Devices

Laser weapon technology was initially developed as a military countermeasure against electrical and optical devices including night vision equipment. Lasers produce a highly collimated beam and can therefore be used over considerable distances (several kilometres). However, this makes accurate aiming with a hand-held device more difficult and some devices use lenses or rapid horizontal and vertical scanning to increase the area of the beam.

As with high intensity portable lighting, lasers do not incapacitate but deter or prevent an individual from carrying out an activity by causing temporary blindness in the central field of vision. Green lasers may be favoured over red as the eye is more sensitive to light at this wavelength and therefore a lower powered device could be used to achieve a similar effect. Some devices also alternate between wavelengths to provide a greater effect and make countermeasures more difficult. An example of a commercially available handheld laser is shown in Figure 17.

Figure 17: ***Commercially available handheld laser***

The greatest concern with this type of weapon is eye safety. Additionally, in bright sunlight it would appear that the power needed to be effective could lead to exposures above desirable levels.

6.2.1 Infra-Red (IR) Laser devices

Figure 18: ***Prototype IR LASER Device***

Infra Red Lasers have been developed to prototype stages that provide a heating effect to the skin. The IR Laser is diverged to a diameter of around 30-40mm and superimposed on a red laser to aid targeting.

The Laser provides a heating effect to the skin but will not penetrate clothing, there is typically a delay of a second or so before the effect is felt with the power being used in prototype devices. The effect itself is enough to ensure that a person will remove themselves from the beam, the beam can be set to energize for a preset period. The health effects of these devices on humans are not fully assessed at present, work is currently being conducted internationally to do this. Particular concerns relate to effects on skin, eyes and internal organs.

6.3 Millimetre wave devices

Millimetre wave technologies operating at 95GHz have been developed over the last few years to provide commercially available devices that will provide an effect at distances up to a few hundred metres. The beam is around half the height of a human in diameter and is generated by a large installation consisting of a power supply, transmitter unit and an antenna. An example of a commercially available millimetre wave device is shown in Figure 19.

A large amount of work has been carried out to assess the safety of the device for use on humans, although this work would need to be reviewed by independent medical experts in the UK prior to decisions on any deployment in this country. The work has considered effects on eyes, skin and internal organs as well as on more susceptible individuals, such as those under the influence of alcohol or drugs, or those suffering from a medical condition or reduced mobility.

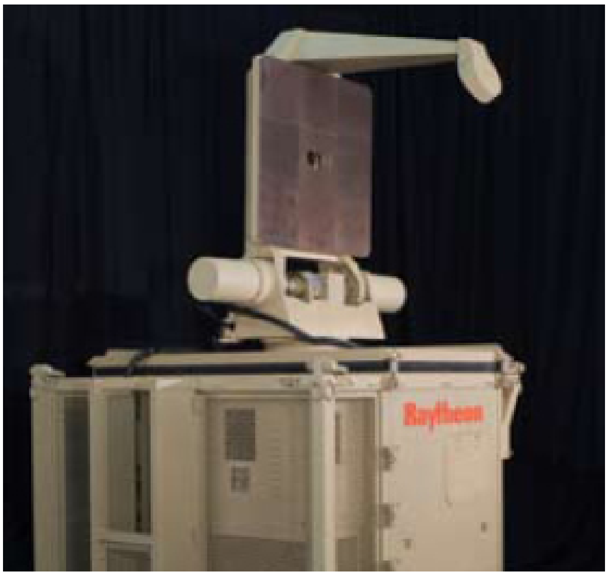

Figure 19: ***Raytheon Silent Guardian System***

The system is designed to heat the outer layers of the skin to the depth of a few tenths of a millimetre to the point where pain occurs but not to the point where permanent injury occurs. It does this by limiting the time of the exposure although it is not clear if this is operator dependent or not. The wavelength of the radiation used is non-ionising and can pass through glass and clothing, although the extent to which this occurs needs to be verified. The medical assessment carried out on the equipment indicates that the wavelength of the radiation prevents it penetrating and heating the body further than the outer layers.

This type of device will also go some way to determining intent by providing an indication that a person continues their actions despite exposure to pain.

7 Water Cannon

Water cannon have been used extensively throughout the world and since 2000 in Northern Ireland typically in public order situations. Devices used for this purpose are usually in the form of a large vehicle, which is typically protected with an armour system. They are designed to use high pressure water to deter people in situations of public disorder. Training and guidance allows this type of device to be used in a safe manner to neutralise and reduce a threat. Additional components could be used, if deemed acceptable alongside, the water. For example dyes or irritants can be added to the jet of water to increase its effectiveness.

Although devices used in riot control are typically vehicle mounted, monitors (the nozzles the water is directed from) are available for fixed mounting, mounting on boats and in smaller portable backpack designs. These are not extensively used in law enforcement, however they have been used in fire fighting for a number of years. These options will also be explored in this section. A list of water cannon manufacturers is shown in Appendix E. This list is as complete as the time scales of this project allowed but may not be comprehensive.

7.1 History

This section outlines the history of UK government work into the use of water cannon as a less lethal option for police use.

1981 – Feasibility study initiated

Initial investigations showed that from the available water cannon the water did not produce the force or range required to keep rioters at a distance or disperse a crowd. In fact, it achieved little more than making the rioters wet. The vehicles themselves were considered to be of use as they attracted missiles and hence took some pressure off the police. A prototype under test in Germany had higher jet power and was capable of preventing the approach of rioters closer than about 30 metres. It had larger capacity and higher pump rate. This model was the only one thought capable of driving rioters back and distancing them from the police.

In September 1981 the Home Office Scientific Research and Development Branch (SRDB, now HOSDB) provided a draft specification for UK water cannon. A committee was set up to develop prototype water cannon for use in the UK.

1983 – Two prototype models delivered

Two vehicles were built, compatible operationally but containing different features to allow comparisons to be made. After delivery these underwent extensive mechanical and road tests. The results of these assessments were presented to senior police officers.

The committee made recommendations for further work on various parts of the machines and advice on operational issues. One of these recommendations was that a medical evaluation of the risk of injuries from the use of water cannon should be carried out before the vehicles were operationally deployed.

1984 – Tentative assessment of the hazards of the Home Office Water Cannon

The Chemical Defence Establishment (CDE, now Dstl) at Porton Down provided this assessment, making predictions that the Home Office water cannon had the potential for significant risks of both primary injury to the trunk and secondary skeletal injuries. To avoid injury the then Home Secretary decided that the use of water cannon in the spray mode (firing over the heads of the rioters) should be evaluated. This was found to be ineffective and a number of other drawbacks for use of water cannon were identified such as quick exhaustion of the water supply, the need to protect refill sources, their recommended usage in twos or threes, their lack of manoeuvrability and their vulnerability to attack.

1987 – Secretary of State's decision

As a result of the testing the Secretary of State produced a statement stating that any benefits in the deployment of water cannon would be outweighed by their operational and tactical disadvantages. It was not proposed to add water cannon to the range of police equipment. Any developments, including the use of water cannon overseas, would continue to be monitored so that the position could be reviewed if necessary.

2001 – HOSDB review

In 2001, during a review of all available less lethal technologies for police use, water cannon were revisited. At this time technical specifications, health and safety issues and operational issues were evaluated.

2004 – Medical evaluations of existing units

In 2004 Dstl produced a number of documents[10,11] which included details of medical implications of specific vehicle mounted models, on behalf of DOMILL[12] for the Home Office and the Northern Ireland Office. This programme of work was believed to be the first of its kind, although water cannon had already been extensively used by police and other agencies in various countries. DOMILL used these data to produce medical statements.

In early 2002 DOMILL produced an interim statement[13], incorporating a review of literature and the guidance to the Police Service of Northern Ireland (PSNI) on the use of water cannon. At the time little information was available on the direct effects of water cannon and information was gathered from other sources such as high pressure water jets, children's toys and surgical equipment, to name a few. This statement provided many conclusions, most notably that *there were no fatalities arising directly from the impact of the water jet from diverse water cannon in appropriate operational use* and that there were *very few reports of injuries that could be classified as life threatening that could be directly attributable to water cannon*. The statement was required for the consideration of the future use of water cannon in the Police Service of Northern Ireland (PSNI). Prior to this

[10] Biomedical Assessment of Vehicle Mounted Water Cannon, Dstl, April 2004.
[11] Medical Implications of the Use of Vehicle Mounted Water Cannon, Dstl, February 2004.
[12] DSAC (Defence Scientific Advisory Council) Subcommittee on the Medical Implications of Less Lethal Weapons
[13] Interim Statement on the Medical Implications of the Use of Vehicle Mounted Water Cannon in a Public-Order Role, DOMILL, 2002

PSNI had deployed the Mol CY NV MSB 18 water cannon, which had been borrowed from the Belgian police authorities.

In 2004 DOMILL produced a statement, superseding their interim statement of 2002, on the medical implications of the use of the Somati RCV9000 Vehicle Mounted Monitor System. PSNI had placed an order for six new vehicles on the basis of the interim statement, and the first two of these were accepted in 2003, subject to a medical statement by DOMILL. ACPO Guidance on the Deployment of Water Cannon was produced at this time[14].

Some technical problems with the first two vehicles delayed the issue of the DOMILL statement. This was released after the vehicles were returned to the manufacturer for modification, then back to PSNI for additional testing to be undertaken.

A literature review and technical assessment were conducted. Based on the literature review DOMILL concluded[15]:

- *There was no evidence ... that any person has been killed by the direct or indirect effects of the impact of a jet from a water cannon in appropriate operational use*
- *There was an extremely low incidence of injuries that could be classed as life-threatening attributable to, or actually caused by water cannon jets.*
- *In public order incidents in which water cannon may be deployed, it may be difficult to differentiate injuries arising directly from the use of water cannon, as opposed to those caused by other less lethal weapons.*

The technical assessment provided details on the pressures and forces of the water at different ranges. These were considered sufficient to displace personnel at medium range. Potential injuries to the eye, head, neck and thorax were considered. The overall conclusion was presented:

> *The hazards identified in the trials have been reviewed in the context of the ACPO Guidance, and the information acquired from the literature survey. It is concluded that the use of the Somati RCV 9000 Vehicle Mounted Water Cannon within the ACPO Guidance is unlikely to result in serious or life threatening injuries.*

It was recommended that any modifications to the vehicles should be subject to medical review.

7.2 Available devices

A number of water cannon and monitor manufacturers were contacted and asked to provide technical specifications for their devices. To date a limited number of responses have been received. Devices that differ from those shown below may be available, however none were identified during this researching period. A number of manufacturers have stated that they are able to build bespoke devices to meet customer specifications. A summary of the

[14] ACPO Guidance on the Deployment and Use of Water Cannon

[15] Statement on the medical implications of the use of the Somati RCV9000 Vehicle Mounted Water Cannon, DOMILL, March 2004

technical specifications for water cannon from the available data is provided below.

7.2.1 Vehicle mounted water cannon

The most commonly used water cannon device for use in riot control situations is a vehicle mounted option. The vehicles tend to be large, with their size largely determined by the capacity of the water tanks on board. The vehicle size is typically around 6 to 9 metres in length, 2.5 metres in width and around 3.6 to 4.2 metres in height. An example of a commercially available vehicle mounted water cannon is shown in Figure 20.

Figure 20: ***Somati RCV9000 Water Cannon***

The capacity of the tank is one of the main limiting factors in the use of water cannon. Vehicles can hold up to around 10,000 litres, although this capacity can vary in size depending upon the circumstances in which the vehicle is to be used. It is usually possible to adjust the flow rate and pressure at which water is expelled from the monitors, and these can be anything up to 4,000 litres per minute. The firing system can also be altered and different modes can be used, which can allow for preservation of water. Most monitors are also capable of producing different spray patterns, for example a mist to an aligned jet. The three main modes that can be used are:

Short pulse – single burst of 5 - 15 litres of water is fired

Automatic pulse – 40 - 70 pulses per minute

Continuous stream – pumping around 900 litres per minute

Most vehicles have an additional tank to hold either a dye or irritant additive, which can mixed with the water system if desired.

The force of the water jet decreases with increasing distance from the vehicle. As such the effective range of the water cannon is limited. At short distances there may be a risk of serious injury, however at longer ranges the water pressure may not be sufficient to deter protesters. A maximum reach of around 90 metres is achievable, however this is dependent upon the nozzle and pressures used. Most units reach maximum range of around 65 metres. Accuracy requires practice as operators often have a limited view and have to rely on directions from the driver to direct the water stream to the target, however a number of vehicles now incorporate cameras to make aiming easier. With practice the crew should be able to effectively target individuals in a crowd, although the dispersion of the water stream prevents the water cannon from being a fully discriminative weapon.

Water tanks require refilling if they are emptied during operational use. Most units are capable of refilling at water hydrants or from open water sources such as rivers, lakes or the sea. The refilling operation itself may take up to

10 minutes to complete, with additional time required for setting up refilling equipment.

7.2.2 Alternative Mounting

Although monitors typically used in law enforcement are mounted on large, purpose built vehicles, they can also be mounted on smaller road vehicles, fixed in localised positions, mounted on aircraft or on boats. This section will focus on these 'alternative' mountings, however boats will be discussed in Section 7.2.4.

A particular type of monitor, impulse cannon, is available in different sizes and can be mounted on various platforms such as all-terrain vehicles or helicopters. These cannon are available on a skid which can then be mounted in any manner. The 12 litre dual cannon system incorporates two 12 litre cannon connected in parallel, a 1,000 litre capacity water tank and four air cylinders, which provide the power. The refilling is controlled from the cannon handlebar, although a remote control release mechanism is optional. The water expelled from the cannon is capable of achieving a maximum range of 60 metres (optimum 10 – 40 metres). Every shot consists of the full 12 litre capacity of the cannon, which then takes six seconds to refill. As the cannon are connected in parallel it is possible to use them sequentially for rapid shooting if required.

Impulse cannon for mounting on helicopters designed for fire fighting applications consist of two 18 litre cannon fitted on a skid with two 155 litre capacity water tanks. The skid is mounted to the base of the helicopter and can be installed within five minutes. Upon depletion of water from the tanks the device system can be refilled whilst airborne. As with the 12 litre impulse cannon the full quantity of water (18 litres) is dispelled from the cannon on each firing. The cannon recharge time for these devices is two to three seconds. The maximum range is also 60 metres. An example of a helicopter mounted impulse cannon is shown in Figure 21.

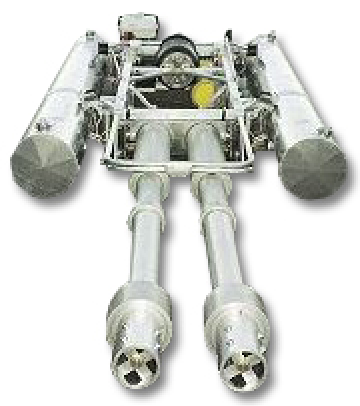

Figure 21: ***IFEX 18 Litre Dual Intruder Impulse Cannon***

Water cannon can be installed in fixed positions and used either indoors or out. One particular device sits on a carbon steel framework that should be mounted on a solid foundation so that any recoil force is absorbed. Using a impulse cannon, the device delivers a 30 litre shot of water in 100 milliseconds in any one firing. The entire contents of the barrel are ejected in one shot. The refilling time for this device was not provided. It is possible to tune the water jet to achieve the most suitable effect hence, using this device, the range over which the water is effective can be between 15 and 45 metres. In a similar manner the area of dispersion of the jet can vary and this is reported to be between 8 and 12 metres in diameter.

An alternative stationary mounted device is typically mounted on roof tops and towers. These use mains water and electricity, although a reserve tank is also installed at the stationary location. The monitors are capable of providing pulsed or continuous jets of water, which are controlled by the operator. The force of the water is claimed to restrain an average sized human at 40 metres. There is also an option of delivering an incapacitant with the jet of water at a previously set (during installation) concentration.

As well as the fixed mounted units, portable ground monitors are available. These devices are relatively small and may be easily stored and transported. They are designed to be maintenance and corrosion free using high grade marine stainless steel with flap valves made from gunmetal bronze. As such the water used can be drawn from natural sources, for example sea water or rivers, or from a storage tank. The devices are powered using either diesel or electric pumps. The maximum range of water dispersed from these devices is around 53 metres (at 10 bar pressure) in ideal weather conditions using fresh water. At lower pressure (3.5 bar) this can be around 37 metres. The jet type is fully adjustable from defined jet to fog. Various angles of rotation are also available, with 360º horizontal movement and vertical settings at 90º and -30º. These monitors are relatively small; when extended to +90º elevation the monitor size is 550 mm height by 450 mm width. An example of a portable ground monitor is shown in Figure 22.

Figure 22: ***Strebor Portable Ground Monitors***

7.2.3 Hand held devices

Man portable monitors are small and easily moveable. They hold the water in a pack which is strapped to the users' back, or in a trolley that can be wheeled along by the operator. One system, primarily designed as a rapidly deployable fire fighting tool consists of a 13 litre water reservoir, a compressed air supply (for power) and an impulse gun. The 13 litre tank, weighing up to 23.3 kg when full, is strapped to the back of the operator who then fires the highly pressurised water at the target area using the impulse gun. An example of a commercially available portable water cannon system is shown in Figure 23. Trolleys are also available for carriage of the water and these have a capacity of 35 or 50 litres.

Figure 23: ***IFEX 13 Litre Backpack and Impulse Gun***

The impulse gun is available in three sizes: ¼ litre, ½ litre and 1 litre. Additional ½ litre attachments are also available which can be added to the 1 litre gun to increase the maximum capacity to 1.5 litres. The water is discharged forcefully in high velocity 'packets' equal in size to the capacity of the impulse gun. The shot of water is also accompanied by a loud bang as the water is expelled. The maximum claimed range of such devices is 15 metres, with the width of the spray being 3 metres at a distance of 5 metres from the gun. Again, these devices have the capability for chemical incapacitants or dyes to be added.

8 Chemical Delivery Devices

Chemical devices, particularly irritants, have been used worldwide for a number of years in both crowd control and close quarter scenarios. The most widely used incapacitants are CS and PAVA in the UK, whilst OC is also used in law enforcement internationally. Other incapacitants exist, such as CN and CR, but these are used to a much lesser extent. The effects, health and safety implications and decontamination issues are presented in Appendix F. A list of manufacturers producing chemical delivery devices is shown in Appendix G, this list is as complete as the time scales of this project allowed but may not be comprehensive.

The use of incapacitants is highly restricted in the UK and devices containing such chemicals are classified as prohibited weapons under Section 5 of the Firearms Act 1968. Only CS and PAVA are deemed to be suitable for use by police in the UK. OC, CN and CR have all been discounted for use by UK police. Considerations leading to this decision are presented in Appendix F. As only CS and PAVA are used in the UK discussions will be limited to devices containing these substances.

Chemical devices are not restricted to this type of incapacitant, and research is continuing in the field of calmatives and tranquillisers. Although some delivery devices have been developed, at this time no known effective calmatives or tranquillisers have been identified for use against humans in a weapon system. Alongside this the British Medical Association concludes that:

> *The use of drugs as weapons does not produce an acceptable or compelling solution to current or foreseeable problems in a military or police context*[16].

Malodorants also fit within the chemical group and these will be discussed accordingly. A malodorant is an extremely bad smelling compound, traditional stink bombs being an example of this. They could be used to deter crowds although they are unlikely to prevent a determined assailant. The possibility of developing malodorants has not been fully explored and very little has been published on possible devices.

[16] BMA Board of Science, The use of Drugs as Weapons - the concerns and responsibilities of healthcare professionals, May 2007

8.1 Personal incapacitant sprays

8.1.1 Aerosols

As only CS and PAVA are currently used in the UK, only devices that contain these incapacitants will be discussed. These devices can contain varying concentrations of incapacitant in a suitable solvent. Using aerosol technology the solution can be released in different spray configurations, for example fogger (or cone) sprays to stream sprays. This, in turn, allows for varying ranges and levels of discrimination.

Figure 25: ***Examples of Aerosol Incapacitant Sprays***

Fogger sprays produce a mist which contains very fine particles of incapacitant and is more readily affected by cross winds. The range of fogger sprays is much lower than that of stream sprays. Stream sprays produce a more discriminating directed jet of spray than the fogger, which typically reach maximum ranges between 3 and 5 metres. They are less affected by cross winds and produce larger particles, which results in less chance of inhalation deep into the lungs. The UK standard for operational police sprays specifies a stream spray.

Incapacitant spray canisters come in a range of sizes and are typically small, hand held devices that are quickly and easily deployed upon aiming and pushing an actuator button. These devices are not refillable, and once the entire contents have been discharged they can no longer be used. Examples of commercially available aerosol incapacitant sprays are shown in Figure 25.

The full effects of CS on the subject being sprayed usually occur within 20-30 seconds of the spraying incident. The effects of PAVA can be instantaneous, providing the PAVA enters the eyes. There are occasions where incapacitant sprays do not produce the desired effects, and subjects that have been sprayed may continue with their actions.

Incapacitant sprays are classified as prohibited weapons under Section 5 of the Firearms Act 1968. Consequently, for use in the UK, only authorised personnel may carry and use the devices, each device must contain a unique identifying label (e.g. serial number) and the devices must be stored and disposed of in accordance with Firearms Act 1968.

All persons using incapacitant sprays must have sufficient training in their use. Currently police officers are trained according to ACPO Guidelines. Sprays are available for training purposes which come in the form of inert canisters containing water. These are designed to perform in the same manner as the live operational sprays. Alongside the inert canisters, general exposure training sprays are available for CS training. These are designed to provide officers with an opportunity to experience the effects of CS without having the sprays directed towards them.

CS and PAVA devices have been used for a number of years by UK police forces. Technical specifications have been produced[17] by HOSDB to ensure canisters used by police officers are durable, contain the required concentration of incapacitant at specified purity and perform as expected to the UK police Operational Requirement.

8.1.2 Pyrotechnic Sprays

Figure 26: ***Piexon pyrotechnic incapacitant sprays***

Some spray devices are available which use pyrotechnic rather than aerosol technology. Currently these are only available with PAVA and OC cartridges. The spray from these devices can either be in the form of a narrow aligned jet or a cone spray. The technology allows increased velocity of the spray and hence greater range in some instances. These sprays are available in two different hand held devices as shown in Figure 26.

Maximum ranges available from the hand held devices are between 4 and 6.5 metres. Due to the nature of the aligned jet the area of dispersion of the sprays at optimum range is around 30 cm diameter. The velocity for the different devices varies from around 40m/s to 120m/s. As such there are health and safety implications which would specify minimum distances at which the devices can be used.

One of the devices is single use only, whereas the other has magazines that can be changed when fully discharged. The solution in each cartridge is emptied upon triggering the device, therefore the quantity of solution discharged from the device is always the same. The spray is emitted instantaneously upon pressing the trigger of the device and the effects are akin to those reported for PAVA solutions.

Inert training cartridges are available for all hand held devices.

[17] HOSDB Standard for CS and PAVA Sprays for Operational Police Use Revision 1, Publication Number 38/08, HOSDB, 2008

8.2 Long Range Incapacitant Devices

Long range incapacitant devices, as their name suggests, are capable of delivering incapacitants at greater distances than the personal incapacitant sprays previously discussed. They are available in many shapes and sizes. These can deliver clouds of incapacitant, in an indiscriminative fashion, or can be used to pick out individuals in a crowd. Discussions on these devices will be separated into three groups based on the delivery method. Devices which disseminate incapacitant pyrotechnically will be reported in section 8.2.1, devices that disperse incapacitant in a solid or liquid form via projectiles will be discussed in section 8.2.2 and devices that fire a spray over extended distances will be discussed in section 8.2.3.

8.2.1 Pyrotechnics

Pyrotechnic chemical devices have been used as a method of dispersing clouds of incapacitant, typically in riot control or room / building clearance. They primarily contain CS or OC as incapacitating agents, there are no known pyrotechnic devices containing PAVA at present.

Figure 27: ***Examples of pyrotechnic chemical devices***

Pyrotechnically deployed CS has been used in Northern Ireland and is extensively used in Europe. Its effects and other details associated with its use are well documented.[18]

The devices vary in shape and size, however they are typically small enough to fit in the hand. Two examples of commercially available pyrotechnic devices are shown in Figure 27. They contain varying amounts of incapacitant, up to 90 grams in solid form. The time over which the incapacitant is discharged is dependent upon the device being used, however this can range from instantaneous up to around 40 seconds. Some devices, once discharged, split into a number of sections and each section discharges a quantity of irritant, thereby increasing the area of dispersion of the device. These devices can be used both indoors and outside, however this is dependent on the amount of CS contained in the device, the level to which it is dispersed and the level of heat that is produced by each device,

A number of devices can be either thrown or launched which provides the ability to use the device at short or long range. Their range is approximately 25 to 40 metres when hand thrown and between 50 and 300 metres when launched.

[18] Himsworth H. Report of the enquiry into the medical and toxicological aspects of CS (orthochlorobenzylidene)

The effects to persons in the vicinity of pyrotechnic CS devices are much the same as effects seen from CS in spray form. Eye discomfort, excessive lachrimation, blepharospasm, burning sensation in the nose and throat and salivation are among the symptoms experienced. Pyrotechnic devices cause the CS to disperse over large areas, hence all persons within the vicinity of the discharged devices will be affected. These effects and other details associated to the use of pyrotechnic CS devices are well documented as a consequence of extensive use in Europe and experience in Northern Ireland.[17]

Due to the level of dispersion of CS from these devices it is advised that the user wears personal protective equipment such as a respirator to prevent their incapacitation. Alongside this, the devices become very hot when discharged and users are advised to wear heat resistant gloves when handling them.

8.2.2 Liquid and solid based incapacitant projectiles

Long range chemical incapacitants are also available in the form of projectiles, which can be launched from 40 mm or 37 mm launchers, 12 gauge shotgun or specialised launching platforms. The irritant is included either in liquid (dissolved in solvent) or solid powder form, at varying concentrations.

Figure 28: ***Examples of incapacitant projectiles***

There are a few different types of projectiles; those designed for barricade penetration and non-discriminative incapacitant dispersal, those for longer range incapacitant dispersal with little discrimination and those designed to deliver a kinetic impact as well as chemical incapacitant for discriminative use against persons. Examples of commercially available incapacitant projectiles are shown in Figure 28.

Barricade penetrating rounds are available in various sizes. Typically they contain CS or OC, no devices containing PAVA were identified. The rounds are designed, as the name suggests, to penetrate barriers for example windows, doors or internal walls. Upon penetration of the barrier the chemical content of the round is dispersed behind the barrier. The maximum effective range of these rounds are around 50 metres (depending on the round used). The effects of these rounds are typically seen instantaneously. It is advised that users of these devices wear hearing protection and respirators. These devices are not designed for firing directly at people as they could cause significant injury.

Some systems allow the user to disperse a cloud of incapacitant (typically CS) from a safe distance, where it is not feasible to approach the target area. These are available not only as single projectiles but also multiple projectiles that can be launched simultaneously. This varies the level of dispersion of incapacitant achievable from any one firing. These rounds reach ranges of between 1 metre and 60 metres. All persons in the vicinity of the incapacitant cloud should be affected. These rounds are typically used in crowd control environments.

Various projectiles are available that allow the user to specifically target individuals and achieve both impact and incapacitating effects. These are available in CS and OC, with the potential of including PAVA, in either liquid or solid form. They are typically fired from specialised launchers, 40 mm or 37 mm. The maximum effective range is around 50 metres, dependent on the system being used. Deployment timing is generally around 30 seconds (for loading and firing). Time to effect can vary depending on the amount of incapacitant contained in the device and the level of dispersion of the incapacitant. Various shaped projectiles are available, ranging from small and spherical rounds to larger baton shaped rounds (akin to many kinetic energy rounds). As these rounds are directed at persons there is a risk of serious injury, particularly if they are directed towards the head or a vulnerable area of the body. Typically, if used in accordance with guidelines, these devices cause bruising and potential lacerations to the skin from the impact of the device.

In response to recommendations made in the Patten report[19], the UK government has started a development programme for a Discriminating Irritant Projectile (DIP). The objective for the DIP is to deliver a discrete localised cloud or burst of sensory irritant in the immediate proximity of an individual aggressor. The current design concept for the DIP comprises a cartridge case and a rigid, lightweight projectile with a crushable nose section containing the irritant. On impacting the target, the crushable nose section compresses in such a manner as to disperse a small localised cloud of irritant. An example of the current DIP design concept is shown in Figure 29. It has been decided to remain with the same launch platform used to discharge the AEP, the L104A1 system. It has also been agreed that the DIP will only be available to suitably trained firearms officers, for use in situations where a significant threat to life or risk of serious injury exist. It is envisaged that the DIP will have an effective engagement range up to 40m. The DIP is currently planned to enter service in late 2010.

Figure 29: ***Design Concept for the DIP***

[19] The Report of the Independent Commission on Policing for Northern Ireland September 1999

8.2.3 Long range sprays

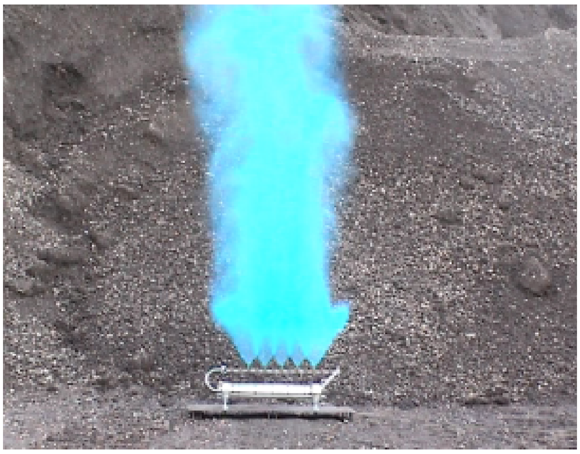

Figure 30: ***Piexon Area Denial System (ADS)***

Long range spray devices powered by pyrotechnic technology allow sprays to be dispersed up to 30 metres from the firing point. These new and near to market technologies could possibly be of use in boundary security, vehicle protection and riot control applications, if deemed suitable. Devices are available in a number of forms from trailer mounted units and man portable devices to water cannon style incapacitant spray launcher. An example of a near-market prototype device is shown in Figure 30.

The trailer mounted unit consists of two modules filled with a payload of irritant or dye. Each trailer can be fitted to a remote controlled robot vehicle and used for riot control. Up to ten trailer units can be fixed to one robot. These devices have an independent power supply and can be operated remotely or autonomously. Spray types from these devices can vary and the attainable ranges are between 5 metres for mist sprays and 20 metres for aligned jets. Production can be to customer requirements.

Devices which are man portable, and therefore easily moved and positioned, are available for perimeter security. These can be anchored to the ground using thorns in concealed locations, if required. Arrays of these devices could be used to achieve the required effects. This same type of device can be mounted on the front of a vehicle for protection.

Devices similar to mini water cannon are also available, and these are capable of firing incapacitant or dye to a maximum distance of around 30 metres.

8.3 Area protection

Devices containing CS or OC are available which can be automatically triggered when people enter protected areas such as rooms. When unauthorised persons enter a room or area protected using this system, automatic warning audio messages are initiated. The warning messages are followed by release of irritant into the room. These devices are designed for use in rooms up to 200 m^3, however additional devices are available for larger rooms. The device is relatively small (cylinder diameter of 160 mm x 330 mm length, weight 6.7 kg) and is fixed to a wall. An example of a commercially available chemical area protection device is shown in Figure 31.

Figure 31: ***Sidag HouseGuard ZR 010***

8.4 Malodorants

During this review, little information was found on available products or research into this area. The following is a summary of a previous evaluation conducted by HOSDB.

The US army proposed that any malodorant used should be perceived highly unpleasant by most people. It should be quickly dispersed and detected, not easily habituated and not incapacitating or sensory irritant.

Studies found a number of odours that were repellent. These caused transient symptoms such as nausea and gagging. The studies also reported reduction in respiratory volume, an increase in respiratory rate, change in the electric resistance of the skin and other systems consistent with tachygastria (nausea). The degree of these responses will be determined by the concentration of the odour. The possible effects on people suffering from respiratory illnesses should be considered and the toxicity of the chemicals must be established prior to the use of such materials. There may also be issues around decontamination following deployment, especially in residential or heavily populated areas.

A number of companies specialise in creating chemical smells and flavours for the food and perfume industries. These may be capable of developing suitable odours in addition to those already on the market. Means of independently delivering these smells could include similar methods to delivering incapacitants for example in spray form or within an encapsulated round. Some manufacturers offer malodorants as an additional component within other devices.

9 Pyrotechnic Devices

A pyrotechnic is a device containing a mixture of chemicals, that when ignited, react exothermically to produce an effect. The effect of a pyrotechnic is to distract or disorientate by overloading the sight and hearing senses. This could be used to help determine intent and maybe even deter persons from continuing in their actions.

The effect produced by a pyrotechnic may be light, heat, gas, sound, Infra Red (IR) decoy or Radio Frequency (RF) decoy or a combination of the above. For the purposes of this report, IR and RF decoy devices have not been detailed as they act to hide positions from weapon/detection systems. All pyrotechnic devices are indiscriminate and will affect anybody within range of the discharge. A list of pyrotechnic device manufacturers is shown in Appendix H. This list is as complete as the time scales of this project allowed but may not be comprehensive.

Although the design of pyrotechnic devices varies between devices and manufacturers they generally contain a method of ignition, a control mechanism and a payload to convey the effect. The typical composition of a pyrotechnic device is shown in Figure 41.

Pyrotechnic devices can be initiated using three different methods:

Electrical - an electrically ignited device would need to be placed and primed prior to detonation. A detonator is wired by authorised personnel and when ready current is sent through the firing leads to ignite the initiator within the pyrotechnic device.

Igniferous – this type of initiation is the same as striking a match and would be part of the manufacture of the device.

Mechanical - also known as impact initiation. When a device is hit with enough force this will cause ignition.

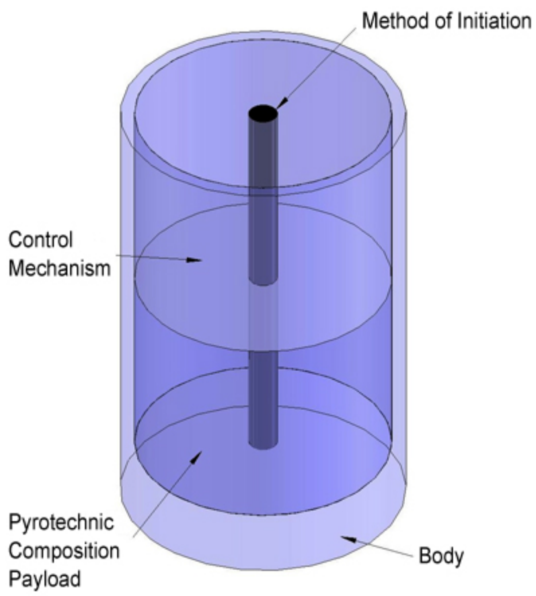

Figure 41: ***Typical composition of a pyrotechnic device***

A control mechanism within a pyrotechnic device can be used to alter the delay between ignition and detonation. This is achieved by varying the burn time of the explosive train within the device.

The body of pyrotechnic devices may be metal, cardboard or rubber. Rubber and cardboard-bodied devices split or fragment relatively harmlessly compared to metal bodied devices on initiation, although they sometimes contain sub-munitions that can fragment when discharged. With metal-bodied devices there is a danger of metal fragments causing shrapnel injuries. Blast injuries to sight or hearing may be caused from discharge when in contact with or very close to a person. Also, pyrotechnics employed to create a flash may set fire to paper, fabrics and other combustible materials in the vicinity of the blast.

The following sections outline different classes of pyrotechnic devices that are currently commercially available and highlights performance capabilities against key aspects of the ACPO Operational Requirement for less lethal options.

9.1 Cartridges

Pyrotechnic cartridges are available for launching from signal pistols, 12 gauge pistols or 12 gauge shot guns. Some of these weapons are classed as firearms under the Firearms Act 1968 and as such, operators would require a firearms certificate to operate lawfully or be exempted for other reasons (e.g. police officer). These devices generally take less than 10 seconds to load and fire.

Figure 44: ***Two examples of commercially available 12 Gauge pyrotechnic flares***

These cartridges have a range of effects including flash, bang, screech and smoke in a range of colours. These devices could be used to attract attention, as a distraction or as a screen. It should be noted that smoke is unpredictable and affected by the weather conditions. Also some commercially available smoke devices contain toxic chemicals and the possible ill effects on people who have repeated exposure or respiratory problems (e.g. asthma) should be considered. These are also available containing chemicals such as irritants, this is covered in Section 8 of this report. The range of these devices is generally around 70m but extended range versions are available that reach up to 300m. Cartridges generally measure around 76mm in length and cost around £2 with a shelf life of 3 years. Two examples of commercially available 12 Gauge flares are shown in Figure 44, and an example of signal flare is shown in Figure 45.

Figure 45: ***Examples of a commercially available signal flare***

9.2 Simulators

Simulators can be used to copy the effects of small explosions or gun fire. These devices are also known as stun grenades, concussion grenades, distraction devices or flash bangs. These devices are again classed as firearms under Section 5 of the Firearms Act 1968 and as such, operators would require a firearms certificate to operate lawfully or be exempted for other reasons (e.g. police officer). These devices aim to disorient and/or incapacitate the target(s), usually by flash blindness (lasting seconds) or temporary deafness (lasting minutes) along with the disorienting effects of intense blast waves.

Stun grenades are available in a range of forms and sizes depending on application. Typically, smaller grenades have impact up to 10m from the centre of the detonation, with light intensity of 2 million candela and sound levels up to 175dB at 2m. More powerful grenades are available with light intensity of up to 8 million candela and sound levels of 185dB at 2.5m. These devices have a range of 25 to 40m when hand thrown and can be launched up to 130m. Work is currently being carried out by manufacturers to extend the range of these types of pyrotechnics. Due to the high sound pressure levels associated with the use of stun grenades, safe systems of work and risk assessments should be conducted prior to use.

10 Other

This category encompasses devices such as nets, bolas, glue, grease and other options used to physically prevent or hamper people moving.

10.1 Nets and Wire Entanglement Systems

The net and bolas systems available do not tend to work well on people who are moving. At close range there is likelihood that the devices will not be sufficiently deployed to entangle the subject and may actually impart considerable kinetic energy, causing trauma injuries. They cannot be used in confined spaces or in areas where they may become entangled. Their range is also somewhat limited, with a maximum of around 10 to 15 metres. Examples of commercially available nets and entanglement systems are shown in Figures 46 and 47.

Figure 46: ***An Eastern European muzzle-launched net system***

Most systems use weights around the net to aid its spread, which could cause injury to bystanders or the targeted individual. A number of launch systems are used to deploy them and several require purpose-made weapons to fire them. Some may be fired from conventional firearms either in cartridges or by using blank rounds to discharge them from the muzzle. There are some concerns regarding the latter method of deployment, as blanks (as opposed to grenade launching cartridges) are not intended for firing projectiles. Most are filled with a fast burning propellant that must generate sufficient pressure to cycle the weapon. Obstructing the muzzle of the weapon with a significant mass could potentially exceed the proof pressure of the weapon and cause irreparable damage and/or injury to the firer.

Figure 47: ***Commercially available net launcher***

Some of the more extreme variations on the entanglement theme utilise other additional methods of incapacitation. These include nets impregnated with adhesives or chemical irritants and products incorporating electrical stun devices to incapacitate the subject as well as restraining them.

10.2 Glue and Grease Systems

A number of prototype glue and grease systems have been developed and demonstrated over the last few years. Prototype glue and grease systems have all lacked a quick method of 'decontamination'. As such, their use would have to be carefully considered as areas and objects coated in glue or grease may need to be used by official personnel or as an escape route. No known commercially available systems are currently available.

Figure 48: ***Demonstration of Prototype Glue Gun***

An example of a prototype device is the 'sticky foam' or 'glue gun'. The foam is stored under pressure in a canister and expands to over 30 times its stored volume when dispensed. It can be discharged from a backpack or shoulder-carried weapon. A demonstration of a glue gun is shown in Figure 48.

It incapacitates by entangling the individual with extremely tacky material at a range of up to 10 metres. The prototype system is capable of multiple shots but due to its extreme tenacity it will tend to stick to anything with which it comes into contact and requires considerable effort to remove it from skin and other materials. If the foam comes into contact with the mouth or face there is a serious risk of suffocation.

Low friction substances such as non-hazardous chemical sprays, foam or grease can be applied across surfaces to deny access to specific areas. This requires some previous knowledge to allow sufficient planning for its deployment. While it may deter a crowd or individuals from crossing a line, it equally prevents users from going forward to restrain or disperse the group.

11 Discussion and Conclusions

This report has provided an overview of the technical aspects of less lethal technologies and currently available or near-market commercial devices. A large amount of information has been gathered about a wide range of less lethal options. Information has been obtained from a number of sources in an effort to gauge performance against key aspects outlined in the ACPO Operational Requirement for less lethal options. Due to the limited resources and timescales available for this review it is important to note that not all information obtained has been verified by HOSDB and should be used for indication purposes only.

Since the initial review of less lethal technologies against the ACPO Operational Requirement in 2001 a number of less lethal options have been introduced into service with UK police. The introduction of these options followed extensive work within UK government, the police service and with independent experts and organisations.

One of the most notable new technologies to be introduced by the UK police service has been electrical devices. The Advanced TASER M26 was introduced in 2004 following a 12 month trial with 5 police forces and the TASER X26 was introduced in 2005 following a detailed HOSDB assessment and positive DOMMIL statement. These devices have allowed police firearms units on a number of occasions to deploy a less lethal option to effectively and safely deal with threats to members of the public and themselves without recourse to lethal firearms. The TASER X26 still represents the best performing and most applicable wired electrical device commercially available. The manufacturers of the X26, Taser International are currently developing a wireless electrical device, the eXtended Range Electronic Projectile (XREP), which may offer an increased range compared to the X26 and hence could more closely align to the ACPO Operational Requirement. Unfortunately, this device is still under development and a commercially available system is unlikely to be available to UK police before 2010.

In 2005 the Attenuating Energy Projectile (AEP) was introduced to UK police following a three year development programme by UK government. This review has shown that limited commercial advancement has occurred in the area of impact devices since the review of less lethal technologies in 2001. The Attenuating Energy Projectile (AEP) still surpasses the performance of any commercially available systems in regard to the ACPO Operational Requirement for Less Lethal Options.

PAVA chemical incapacitate sprays were introduced in 2002 expanding the range of personal chemical incapacitate sprays available for police use. The devices available to UK police still represent the most applicable devices against the ACPO OR. Little to no commercial advancement has occurred in the area of long range chemical delivery, the development of the Discriminating Irritant Projectile (DIP) by the UK Government still appears to offer the best option to provide a system to discriminately deliver chemical incapacitants at range.

The area where there has been the biggest advancement in technology is directed energy. Within this technology area, millimetre wave devices would appear to offer a capability to achieve less lethal effects at ranges that are unachievable with less lethal options currently in service with the UK police. These devices could therefore offer the capability to meet the 'Long Range Threat' scenario and the 'greater distance (up to 50m)' requirement identified in the ACPO Operational Requirement for Less Lethal Options. To date commercially available millimetre wave devices have been very expensive and extremely large, and are not suited to policing applications. Most notably they fail to meet the 'Mobility/Flexibility' requirement identified in the ACPO Operational Requirement, which requires the device to be easily transported to the scene of an incident, and ideally portable at the scene. Although a large amount of work has been carried out internationally to assess the safety of these devices, work would need to be reviewed by independent medical expects in the UK prior to any decisions by ministers for UK deployment. Commercial manufacturers are working on producing smaller more portable units, but it is currently unclear when a device might be produced that will be suitable for assessment against UK policing needs.

Appendix A: ACPO Operational Requirement

ACPO Conflict Management

Police Use of Firearms, Self-defence, Arrest and Restraint

and Public Order Sub-committees

"LESS LETHAL OPTIONS - An Operational Requirement "

1. Introduction

1.1 The purpose of this paper is to outline an operational requirement for 'less lethal options' for the police service in the UK, against which potential options can then be assessed. The requirement is intended to cover a wide range of conflict management scenarios, including those associated with self-defence, arrest and restraint, public disorder and the police use of firearms.

1.2 The term 'less lethal options' is employed to include weapons, devices or tactics whose design and intention is to control and then neutralise a threat without substantial risk of serious or permanent injury or death. While the actual outcome may occasionally be lethal, this is less likely than the result of the use of firearms, for example.

1.3 In situations involving public disorder it should be recognised that the ‘threat’ to be controlled and neutralised may arise from the collective behaviour of groups of individuals or from individuals within a group. For this reason tactical options should be capable of:

- preventing groups forming or re-forming;
- dispersing or de-stabalising groups;
- containing groups;
- maintaining a sterile area or keeping groups at a safe distance;
- controlling and neutralising any threat posed by specific individuals within groups.

All the above support the principle tactical approaches outlined in the ACPO Manual of Guidance on Keeping the Peace and the overall intention of managing and minimising risk.

1.4 In this manner, it is intended to progress towards the provision of appropriate tactical options in conflict management from a full consideration of their potential use and effect. This consideration is necessary to ensure that the Police Service has the ability to best protect the lives and rights of all involved with policing incidents by the appropriate use of force (officers, subjects and the public in general). The first stage will involve the development of specifications and appropriate tests to assess how well equipment may meet the Operational Requirement. Further work can then be done to develop the necessary accompanying tactics.

1.5 Operational decisions can then be made based on a range of tactical options shown to be effective - a 'capability set'. This will prevent individual forces or officers having to evaluate the effectiveness of a plethora of potential weapons/devices/tactics themselves, and will assist in maintaining a consistent and professional approach.

1.6 In arriving at the requirements outlined below, consideration has been given to a number of operational scenarios, which should continue to be borne in mind through the necessary deliberations. The discriminating factors arising from such scenarios include the following:

- Close quarters threat;
- Long Range threat;
- Precise / Imprecise Situation;
- Indoors / Outdoors location & environment;
- Weapons;
- Hostage Involvement;
- Immediacy of threat;
- Containment requirement;
- Victim-precipitated killings;
- 'Special Population' subjects (i.e. those whose judgment is impaired by illness, disorder or drugs);
- Group activity;
- Countermeasures by the subject or others.

2. Operational Requirements

2.1 <u>Accuracy</u>

The option should be discriminating over a range between 0 and 25 metres. This range is chosen as an approximation to that within which a firearms containment can reasonably be provided by officers with handguns, accounting for their general accuracy. In public disorder situations accuracy at range will be particularly important since it may be necessary to target individuals within a tightly packed group. Considerable further benefit will arise if an option is discriminating over a greater distance (e.g. up to 50m), allowing it to be deployed as part of a wider containment, and making it more readily transferable to some public disorder scenarios. Naturally, options that are shown to be effective over only part of this range will still merit consideration.

2.2 Immediacy

The option should be rapidly effective - ideally immediate. Although certain scenarios may benefit from a delayed action, these will be limited.

2.3 Subject Population

The option should be effective against the maximum proportion of the population, taking account of both permanent and transitory differences (e.g. ergonomics / drunkenness).

2.4 Ease of Operation

The option should be capable of being operated by one officer. It should be suitable for use by the majority of officers with appropriate training, regardless of physical size or gender. It should not rely on complex motor skills

2.5 Judgement

The option should minimise the number of judgement issues arising from its use (i.e. clear intention / targeting / outcome).

2.6 Injury / Lethality

The option should minimise the risk to any person of serious injury and/or lethality at all ranges.

2.7 Effect

The option should at least temporarily neutralise the threat, rendering a subject incapable of carrying out an immediate threat of violence. The duration of such incapacitation must be sufficient to permit officers to safely approach a subject and restrain them, which may include the need to overcome an obstruction (i.e. locked door / barricade).

2.8 Environment

The option should be effective in all operating conditions (e.g. weather, indoors/outdoors, lighting, temperature etc.) and in confined spaces.

2.9 Mobility / Flexibility

The option should be effective against a moving subject. It should be easily transported to the scene of an incident, and ideally be portable at the scene.

2.10 Cumulative Effects

The use of the option should not preclude the use of other tactical options before/after. It should not increase or reduce their effects if they are subsequently employed.

2.11 Safety / Security

The use of the option, and the equipment required, should be safe to operate and store, and should have the minimum security considerations.

2.12 It is naturally recognised that few, if any, options will meet all of the above requirements. They will, nevertheless, enable the production of a matrix to derive the 'best fit' available, probably involving a combination of options. Every effort should be made to ensure clarity as to the capability of each option and to avoid or minimise confusion as to the appropriate selection by an individual officer. The resulting capability, combined with appropriate tactics and training, should equip officers involved in the widest range of scenarios.

3. Other issues

3.1 The following additional issues need to be considered in arriving at this capability set which will have a bearing on the practicality of adopting specific options:

3.2 Repeat Operation - speed of multiple use - Are repeated applications of the option likely to be required? How feasible is such repetitive operation (by one officer/several)?

3.3 Specialist v. General use - Is the option appropriate for deployment in all officer roles, or only by specialists (e.g. dog-handlers, Tactical Firearms Units, new team)

3.4 Training - What are the training periods associated with the option's deployment, both initially and in terms of refresher training? What training facilities are required?

3.5 Costs

3.6 Legal and Human Rights Implications - Would the adoption of the option require new legal authority (e.g. prohibited weapons)? What are the tactical considerations in the light of Human Rights (e.g. proportionality, least intrusive option)?

3.7 Acceptability (Police and public) - What is the external and internal impact assessment associated with the options considered?

3.8 Visual effect (on subject / third party) - Does the option involve equipment looking like a firearm? Can the option be carried / used covertly?

3.9 After-effects - How long do potential after-effects last? What treatment/training is required to deal with potential after-effects?

3.10 Durability - How robust is any equipment required for an option? Over what period can an option be said to be reliable - what checking is required?

3.11 Authority required to use - Who should authorise the use of the option? Who should review its use, when, and how often?

3.12 Audit Trail – Does the option have a secure system for recording use? Will this enhance a documented system for decision making and management information?

3.13 Quality

Is the build quality adequate, can the option be relied upon to perform the same way every time, does the manufacturer have a system in place to ensure quality and consistency of its product(s).

4. Conclusion

4.1 The issues involved in the Use of Force can be complex - both the level of force and its nature need to be justified if we are to show that it was legal, proportional and in pursuit of a legitimate aim. It is hoped that the above operational requirement can provide the initial basis to explore the options available. This is with a view to simplifying the decision-making process required in operational situations at the same time as complying with the standards required of a professional Police Service.

Appendix B: Kinetic Energy Device Manufacturers

Manufacturer	Web Site
BAE Systems	http://www.baesystems.com/
Combined Tactical Systems, Inc	http://www.combinedsystems.com/main.html
Primetake	http://www.primetake.co.uk/
Verney-Carron	http://www.verney-carron.com
Fiocchi USA	http://www.fiocchiusa.com
Sage Ordnance	http://www.sageinternationalltd.com/sco/index.html
Policske Strojirny	http://www.pos.cz/en_index.htm
Precision Ordnance	http://www.pop-inc.com/POP_Cat_Pg00.html
MK Ballistic Systems	http://www.mkballistics.com
SIMAD	http://www.simadspa.it/
ALS Technologies	http://www.alstechnologies.com
FN Herstal	http://www.fnherstal.com
Beretta	http://www.beretta.com/
Armour Holdings/Defence Technology Corp.	http://www.defense-technology.com
Condor	http://www.condornaoletal.com.br/

Appendix C: Electrical Device Manufacturers

Manufacturer	Web Site
TASER® International	http://www.taser.com/Pages/default.aspx
Stinger Systems	http://www.stingersystems.com/
Law Enforcement Associates	http://www.leacorp.com/

Appendix D: Directed Energy Device Manufacturers

Manufacturer	Web Site
Raytheon	http://www.raytheon.com/
QinetiQ	http://www.qinetiq.com/
Streamlight	http://www.streamlight.com/default_nonflash.aspx
Nightsearcher	http://www.nightsearcher.co.uk/acatalog/
Microfire	http://www.microfire.cn/
Surefire	http://www.surefire.com
Night-Ops	http://night-ops.com/
Cobra	http://www.cobrastunlight.com/
LE Systems Inc	http://www.laserdazzler.net

Appendix E: Water Cannon Manufacturers

Manufacturer	Web Site
Alvis Vickers	not available
Armortek International USA	http://www.armortek.com
Beit Alfa Technologies	http://www.bat.co.il
IFEX Gmbh	http://www.ifex-3000.com/English/index.html
MOL	http://www.molcy.com/en/midden.html
Protech Armored Systems, Armor Holdings	http://www.protecharmored.com
Protechnology	http://www.water-cannon.com
Somati nv	http://www.somati.be
Tenix	http://www.tenix.com
Waltek	http://www.waltek-trucks.com
Ziegler	http://www.ziegler.de
Strebor	http://www.streborfire.com/

Appendix F: Overview of Chemical Incapacitants

	CS	**PAVA**	**OC**	**CN**	**CR**
Full chemical name	o-chlorobenzylidene malonitrile	Pelargonic acid vanillyl amide	Oleoresin Capsicum	Chloroacetophenone	Dibenz[B,F]-1,4-oxazepine
Effects	Peripheral sensory irritant, which causes eye discomfort, excessive lachrimation, belpharospasm, burning sensation in the nose and throat, salivation, constricting sensation in exposed skin.	Potent sensory stimulant which primarily affects the eyes, causing closure and severe pain.	Involuntary closure of eyes, shortness of breath, burning sensation in skin. Respiratory symptoms include burning sensation in throat, cough, wheeze. Effect to eyes include lachrimation and blepharospasm.	Similar effects to CS and CR – irritant to skin, eyes and upper respiratory tract. Irritant effect stimulates tear secretion. Effects are short lived and self limiting.	Similar effects to CS and CN – irritant to skin, eyes and upper respiratory tract. Irritant effect stimulates tear secretion. Effects are short lived and self limiting.
History	Discovered in 1928 by chemists Corson and Stoughton. Introduced into UK in 1958 to replace CN. Used as riot control agent in Northern Ireland in 1969. Introduced in personal incapacitant sprays for use by police in 1996.	PAVA has been used for a number of years in topical medications (very small concentrations). It was introduced in personal incapacitant sprays for use by police in 2002.	Identified as a potential incapacitant in 1921 in America but much of the research was highly restricted. FBI became interested in OC in 1987, and it has been widely used by the American Police since the early 1990s.	First produced in 1871, and marketed as a defence spray in 1965, however is scarcely used today. It is often referred to as MACE which is a tradename.	First synthesised in 1962. More potent and less toxic than CS. There is limited application due to lack of toxicological studies and decontamination issues.
Decontamination	Soluble in water – decontamination with copious amounts of water	Soluble in water – decontamination with copious amounts of water	Soluble in water – decontamination with copious amounts of water	Soluble in water – decontamination with copious amounts of water	Insoluble in water – difficult to decontaminate
Health and safety implications	Toxicology well documented. Considered by Committee on Toxicity as suitable for use as an incapacitant spray 10 times more potent than CN but less toxic. Some adverse reactions have been seen, causing transient blistering to the skin. This has been attributed to the solvent in which CS sprays are dissolved (MIBK). These effects typically clear up within a few days.	PAVA has been through a number of toxicological tests and has been considered by the Committee on Toxicity as suitable for use as an incapacitant spray	OC is derived from a natural product and, as such, its composition is not consistent batch to batch. Due to the number of components and the variability of the sprays it is difficult to obtain toxicological information on this product.	The margin of safety between the incapacitating dose and lethal dose for CN is much less than that for CS. It is more toxic and has also been associated with a number of deaths. Most toxic of these incapacitants. Deaths from pulmonary injury and or asphyxia reported	Lack of toxicological studies in comparison with other agents. Potent lachrimator with least systemic effects

Appendix G: Chemical Delivery Device Manufacturers

Manufacturer	Web Site
Protech Armored Systems, Armor Holdings	http://www.protecharmored.com
SAE Alsetex	http://www.alsetex.fr
Carl Hoernecke Chemisce Fabrik GmbH & Co KG	http://www.tw1000.com
FN Herstal	http://www.fnherstal.com
Take Down	http://www.mace.com/
CDS	http://www.civil-defence.org/index.html
PepperBall	http://www.pepperball.com/
Piexon	http://www.piexon.ch/
Primetake	http://www.primetake.co.uk/

Appendix H: Pyrotechnic Devices Manufacturers

Manufacturer	Web Site
Rheinmetal	http://www.rheinmetall.de
Nico	http://www.nico-pyro.com
Primetake	http://www.primetake.co.uk
Chemring Countermeasures	http://www.chemringcm.com
SAE ALSETEX	http://www.alsetex.fr
ALS Technologies	http://www.alstechnologies.com
Pains Wessex	http://www.pwss.com

Home Office Scientific Development Branch
Sandridge
St Albans
AL4 9HQ
United Kingdom

Telephone: +44 (0)1727 865051
Fax: +44 (0)1727 816233
E-mail: hosdb@homeoffice.gsi.gov.uk
Website: http://science.homeoffice.gov.uk/hosdb/

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