PSDB EVALUATION OF LESS LETHAL TECHNOLOGIES

1 INTRODUCTION

Since the NIO Phase 2 report[1] and the Home Office Police Scientific Development Branch (PSDB) report[2] on prioritisation of less lethal technologies were published in November 2001, PSDB has continued to evaluate commercially available rounds and equipment from each of the five priority technologies against the police Operational Requirement for a less lethal tactical option. These five priority areas are:

- electrical incapacitation devices, particularly tasers;
- kinetic energy rounds;
- long-range chemical delivery devices;
- vehicle mounted and portable water cannon and;
- distraction and disorientation devices, particularly laser/light devices and noise generating devices.

Evaluation of the different technologies has progressed at different rates due to prioritisation of resources and the availability of commercial products and information relating to them within each of the technology areas.

A summary of each of the five priority technology areas is provided, detailing the evaluations that have taken place and the current situation regarding each of the technologies. This provides an update on the testing that has been carried out and the results that have been obtained since the Phase 2 report. PSDB has now completed its evaluation of taser devices, which has utilised a large proportion of the resources within the less lethal weaponry programme. Consequently, the majority of this report details the work that has been carried out on this class of technology.

When PSDB obtain information from a manufacturer relating to their product(s) that is not generally available to the public, this information must be treated in confidence. Similarly, the results that we obtain from our testing of such products are of a RESTRICTED COMMERCIAL nature and so cannot be detailed here. As such, this report can only provide an overview of testing that has been carried out and general trends that have been observed. It cannot detail which specific products have produced particular results. This information can, however, generally be passed to ACPO and UK Police forces to assist them in their decision making about the capabilities of the varying technologies.

2. TASERS

Since April 2001 PSDB has carried out an in-depth evaluation of taser devices. A search of the market revealed that there are currently few manufacturers of such equipment although many companies produce other electrical devices such as stun guns and stun batons. Two companies that dominate in the US, Tasertron and Taser International, were the only two to submit products to PSDB for evaluation.

PSDB has now completed its evaluation of taser devices and the information contained here summarises its findings. The purpose of the evaluation has been to answer, as completely and accurately as possible within the available time, how well tasers meet the police Operational Requirement for a less lethal tactical option. The information gained is intended to provide information to allow the Home Office, ACPO and the NIO to make an informed and balanced decision about the future use of taser devices

within the UK (naturally, if Scottish police forces become interested in tasers then ACPO Scotland and the Scottish Executive would also need to make the same types of decisions based on this evidence).

The information contained in this report has been collated from a variety of sources in order to answer, as fully as possible, each of the points that relate to the performance characteristics of tasers. The information that has been gathered has come from four main sources:

- Information received from the manufacturers, generally relating to the various characteristics of each of the devices. Where necessary, this information has been verified or validated. A summary of the manufacturers and models evaluated can be found in Section 2.1.
- Testing carried out by PSDB on the various models of taser to determine characteristics such as absolute accuracy, performance under ideal and extreme conditions and measurement of the electrical output. Much of this testing is detailed throughout Section 2.2.
- Police handling trials carried out in March 2002, with the assistance of 64 police and prison officers from 20 different UK police forces. These trials involved the officers firing four different models of tasers at cardboard, human-sized targets. 16 different exercises were carried out in total, requiring the use of 1,253 taser cartridges. Each officer also filled in a questionnaire, which consisted of 17 different questions and an open comments section. A summary of these trials are given in Section 2.3.
- Information received from international contacts, based on their operational experiences of using tasers and evaluations that they have carried out prior to their introduction. This information includes data about many police officers that have been voluntarily subjected to the effects of the taser. Details on the international use of taser devices are given in Section 2.4.

This report addresses the scientific and technical aspects relating to taser devices. It deliberately does not address any policy considerations, such as whether tasers would be acceptable for use in the UK, nor many operational aspects, such as who should carry the devices if they are to be deployed. These aspects need to be addressed by the appropriate bodies - the Home Office, ACPO or the NIO - using this document to inform them.

In considering the suitability of taser devices for use in the UK, it must be borne in mind that there is currently a ban on the export of electroshock devices, including tasers, from the UK. This means that, under existing laws, although forces would be able to import the devices, they may be unable to export them again, for instance to return a faulty weapon to the US manufacturer for repair.

2.1 Manufacturers and Models of Taser

2.1.1 History

John Cover constructed the first prototype taser in 1970. The name taser is an acronym for “Thomas A Swift’s Electrical Rifle” after the Tom Swift fantasy stories that Cover read as a child. After 1970, the taser device was demonstrated to a number of groups including law enforcement agencies, who did not consider the technology to be a viable option at that time. Cover continued to develop taser technology aimed at civilian markets, particularly the United States airline industry[3].

Sales of taser devices to the civilian market were more successful, although problems occurred when the United States Consumer Products Safety Commission halted the sales of tasers for a short period in 1975. This was partly prompted by the fact that tasers were used in a number of robberies throughout the United States. Subsequently, tasers were classified as a Title II firearm in the US (the same category as a machine gun), which was later reduced to a Title I conventional firearm, thus making it easier to sell

to civilians. Restrictions were also put in place to limit the sale of taser devices to other countries, since the State Department felt that the taser could be used as a weapon of torture overseas.

In 1976 some US police departments and correctional facilities began successfully using the taser. In 1980, the Los Angeles Police Department bought 700 tasers for general patrol duty use. Their success led to renewed interest from other forces and use of tasers within the US law enforcement community has continued to grow. The US State Department now also allows exportation of taser technology to preferred overseas countries.

There appears to have been a resurgence of interest in taser technology in North America and Canada in recent years, particularly with the appearance on the market of new models and the introduction of higher-powered tasers. A number of forces that previously used the original lower-powered taser units have already changed, or are in the process of changing over to the new higher-powered devices, either from the same manufacturer or a different one. The taser was first introduced in Canada in 1998.

The two major suppliers of tasers to the United States law enforcement sector are Tasertron and Taser International, both of whom submitted products to PSDB for evaluation. In many respects, the devices made by each of these manufacturers are very similar as they are essentially designed to do the same thing, however there are some important differences that set the two apart. Details of these two companies and the models of taser that were evaluated are given below.

2.1.2 Tasertron

Tasertron was formed in 1986. Tasertron does not sell its products to the civilian market, only to authorised law enforcement agencies, corrections agencies, airline security, government departments and the military. Until 1998, Tasertron was the only supplier legally able to sell taser devices to North American law enforcement agencies[3]. This legal agreement has since expired and other companies are now also allowed to sell their products to this market. In 1999 Tasertron claimed to have supplied tasers to over 400 law enforcement agencies throughout the United States. They also claim that there have been over 50,000 field deployments of their devices.

In March 2002, Tasertron became a wholly owned subsidiary of Taser Technologies Incorporated, but will continue to manufacture under the name Tasertron.

PSDB evaluated four different models of taser produced by Tasertron. These were the TE86, TE93, TE95 and TE95HP. Essentially, the TE95 model is identical to the TE86 except that it has fitted as standard a connection port for the laser sights. This has to be retrofitted at the factory if required for TE86 models. The TE95HP model is also identical to the TE95, except that it has a higher power output. Figures 1 and 2 show the TE93 and the TE95/95HP models.

FIGURE 1: ***The TE93***

FIGURE 2: ***The TE95/95HP***

Details of this company and its products can be found on their website at www.tasertech.com or www.tasertron.com

2.1.3 Taser International

Taser International was formed in 1993 and at that time the company was called Air Taser Inc. The company introduced the Air Taser 34000 series in 1995. Their products were initially aimed at the civilian market until the expiry of Tasertron's exclusive agreement allowed them to supply to law enforcement agencies. Because the Taser International cartridges use compressed nitrogen as a propellant, their tasers are not classified as firearms by the Bureau of Alcohol, Tobacco and Firearms in the US, making them more readily available to the public[3]. Taser International sells the 34000 series and the M18 models of taser to civilians but not the M26 model, although recently they have made their M26 models available to aviation security. They also sell only 15ft cartridges to civilians, not 21ft cartridges.

Taser International are now focussing much more on the law enforcement market. In 1998 they changed their name from Air Taser Inc. to Taser International Inc. and began selling their products to police agencies in the US. The first "Advanced Taser" units (which consists of the M18 and M26 models) were sold to the US law enforcement market in 1999 when the New York City Police ordered 30 units for field testing. By the end of 2001, Taser International claimed to have supplied tasers to over 1000 law enforcement agencies in the United States and abroad. This included over 20 agencies that are said to have purchased taser products for every patrol officer. In addition to this, Taser International say that a further 100 police departments are evaluating the Advanced Taser models.

PSDB evaluated three different models of taser produced by Taser International, the 34000 series, the M18 and the M26. The M26 is identical to the M18 except that it has a higher power output and also has a dataport connection. The dataport records the date and time of previous firings of the taser. Figures 3 and 4 show the M18/M26 model and the 34000 series.

FIGURE 3: ***The M18/M26***

FIGURE 4: ***The 34000 Series***

Details of this company and its products can be found on their website at www.airtaser.com or www.taser.com

2.2 Taser Performance Characteristics

2.2.1 Introduction

The taser is a battery-operated device that generates a high voltage electrical current. 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 wire. When the device is fired the barbs are propelled towards the subject, pulling the wires behind them, and attach themselves to the skin or clothing of the targeted individual. When the barbs strike a person, a current can be sent down the wires and through the person's body between the two barb points. The electricity flows in a series of pulses (that can be heard as a series of 'clicks'). If the frequency of these pulses goes down, the effectiveness of the device will reduce. This can happen if the batteries run down or in a very cold environment.

All tasers can be used in "probe" mode, meaning that they fire the barbs and their trailing wires out of the cartridge attached to the hand-held unit. In addition, some of the models can also be used in "touch

stun" mode. This means that the electrical contacts on the hand-held unit can be pressed directly onto the subject. However, as the electrodes are only around 50mm apart, this mode of use is unlikely to provide the same incapacitation effect as when used in probe mode.

The different models of taser have different performance characteristics and some models perform better than others. A summary of the many important aspects of performance now follows, with details of the typical results that can be achieved with the different models of taser.

2.2.2 Accuracy

The absolute maximum range of any currently available model of taser that PSDB are aware of or have tested is 21ft (6.4m). This is the maximum length of the wires within the cartridge and cannot be exceeded. The barbs are positioned within the cartridge with a pre-defined angle of separation between them so they are closer together at shorter distances and further apart at greater distances. 15ft (4.6m) cartridges are also generally available and some of these have a wider angle of separation between the barbs such that the barbs will be further apart at any given distance compared with the 21ft (6.4m) cartridges. 15ft cartridges may be preferred when the taser is used at closer ranges to ensure that a significant number of muscle groups are likely to be affected.

Tasers generally use projected laser sights to aid with the accurate placement of the barbs. Some taser models employ a single laser sight that is designed to show where the top barb will land on the target whereas other models use a dual sight to indicate where both barbs will land. Wider separation of the barbs on the target reportedly results in more effective incapacitation because the electricity affects more muscle groups. However, it is also essential that both barbs attach onto the subject's clothing or penetrate their skin, otherwise the circuit cannot be completed and the electricity will not flow through the target.

Figures 5 and 6 show the typical separation of barbs that can be expected when the taser is fired at various distances from the target. Figure 5 shows the results for 21ft (6.4m) cartridges and Figure 6 shows results for 15ft (4.6m) cartridges that have a wider angle of separation between the barbs than the 21ft cartridges. The point of aim in these tests was the centre of the chest area just above the nipple line (co-ordinates 0,0). This data was collected under ideal conditions, i.e. all tests were carried out indoors at room temperature, with no wind effect and with the taser clamped firmly onto a tripod.

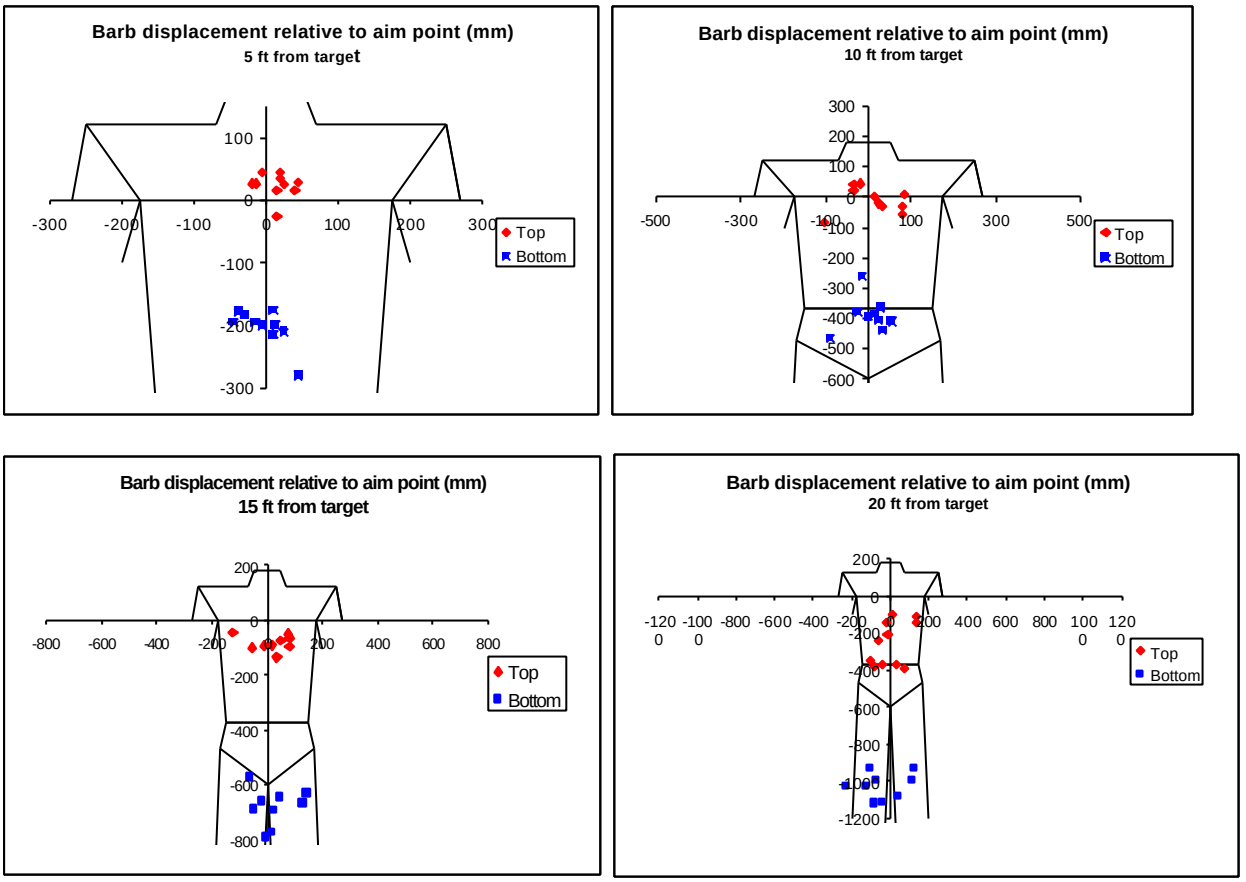

FIGURE 5: ***Position of Taser Barbs at 5ft (1.5m), 10ft (3.0m), 15ft (4.6m) and 20ft (6.1m) from the Target Using 21ft (6.4m) Cartridges***

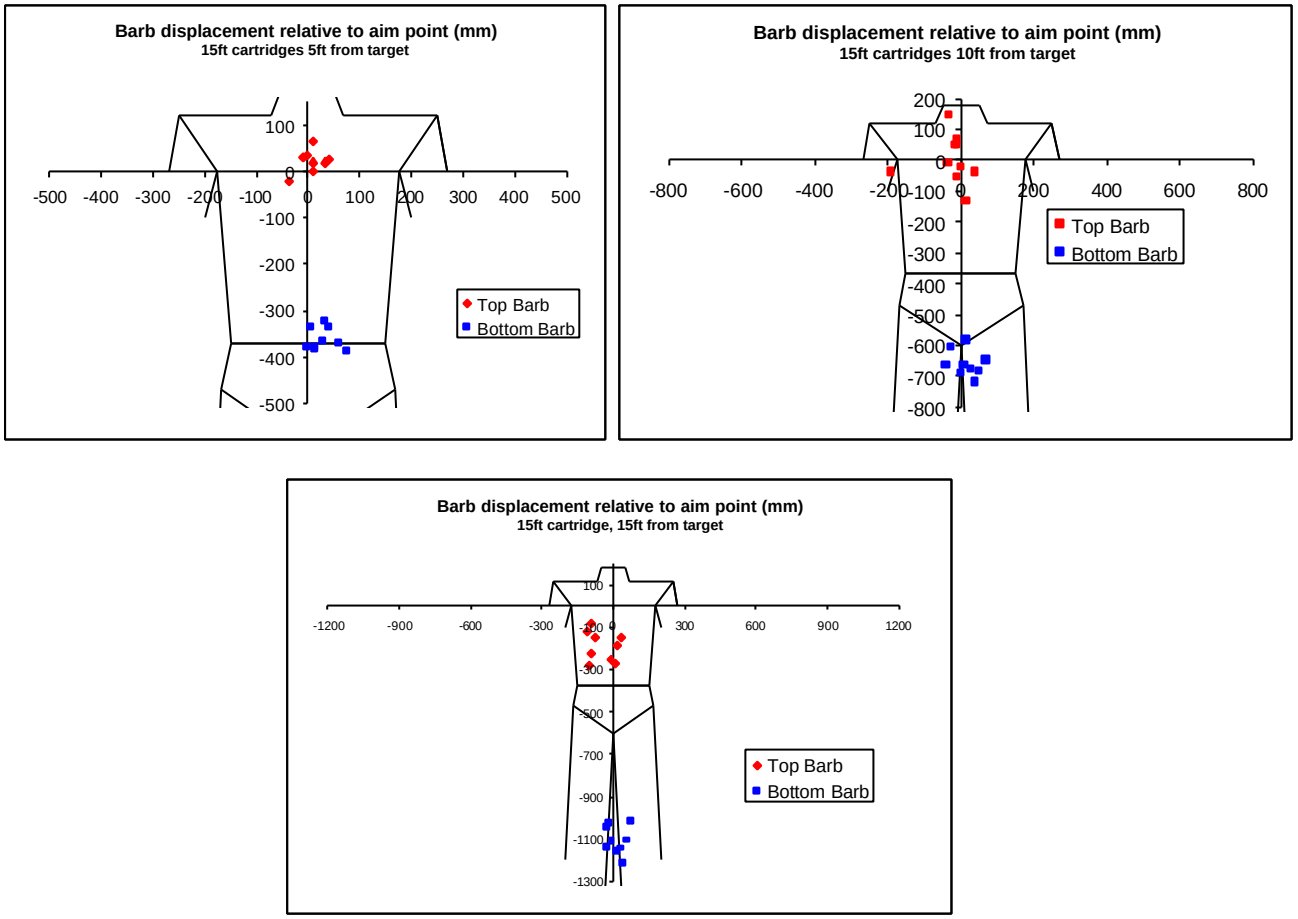

FIGURE 6: ***Position of Taser Barbs at 5ft (1.5m), 10ft (3.0m) and 15ft (4.6m) from the Target Using 15ft (4.6m) Cartridges***

It can be seen from these figures that the taser barbs will not always strike the target in the area indicated by the laser sights despite the tests being carried out under ideal conditions. This is particularly so at distances greater than 15ft (4.6m) when the top barb tends to drop below the top laser sight. Section 2.3.5 provides a summary of the accuracy that was achieved when different tasers were hand-fired at man-sized targets in a range of exercises during a series of handling trials.

2.2.3 Effectiveness

Effectiveness of the taser is influenced by a number of factors. These are outlined below:

i) Effect

The effect that the taser generally has on a person is to make them fall down to the ground or to 'freeze' them in place while their muscles are contracting. This effect on the subject continues while the electricity is flowing. As soon as the electricity ceases to flow, however, the subject **may** make an immediate recovery. Generally, the subject is likely to be dazed and confused due to the severity of the effects and may not completely recover immediately. It is also possible that their muscles will be aching and they may feel lethargic. The manufacturers of tasers recommend that the officers approach the subject whilst the electricity is being applied, rather than waiting for it to stop before advancing as this may be too late and the subject may have recovered. Video footage from the US shows that officers should be able to hold onto a subject while they are being tasered without receiving any of the electric current themselves, providing they do not touch the area between the two barbs, as in this case they may provide an alternative path for the electricity to flow along.

The taser will only be effective if both barbs are attached to the target, either through their clothing or via penetration of the skin. If only one barb is attached, the circuit will not be complete and the electricity will be unable to flow.

Some models of taser have a pre-timed continuous discharge of electricity that lasts for a fixed amount of time after the trigger has been pulled. If required, this can be stopped early by flicking on the safety switch. Other models will discharge electricity only for as long as the operator's finger remains on the trigger, or until the batteries are depleted or the taser breaks down. With all models of taser, it is possible to reapply charge to the subject repeatedly, providing both barbs are still attached to the person. If one or both barbs have become detached from the target, then a new cartridge will have to be fired (unless the device is used in touch stun mode).

It is worth noting that the taser can be effective without the need to actually fire a cartridge. The threat of use, and the use of the laser sights, may induce compliance in some cases. The visual effect of the taser, perhaps by demonstrating the arcing effects when the electricity is flowing (which results in a loud crackling noise and blue flashes) is also enough to deter some people. When used in this way, however, the taser must generally be unloaded. Some models of taser can also be used in 'stun gun' mode, which allows a touch-stun capability on the subject without the need to have a cartridge inserted in the device. This mode of use is unlikely to provide the same incapacitation effect as is achieved when the barbs are fired, as a much smaller number of muscles are affected by the electricity. Section 2.4 of this report provides some details on the effectiveness of these different modes of use from overseas operational experience.

ii) Immediacy

Providing the taser unit works correctly and both barbs attach to the target, the taser can be a very rapidly acting device. The time to incapacitation of the subject is likely to vary depending on the power output of the taser used. In video evidence and reports from the USA coupled with statements from police forces there, the lower powered tasers appear to take a few seconds to control the subject, whereas the higher powered models appear to have an almost immediate effect[4].

One Canadian field study[3] of a lower-powered taser found that, on average, the taser took between 3-5 seconds to control the subject, although in one case it took as long as 15 seconds. A further Canadian study[5] of a higher-powered taser found that volunteers immediately and involuntarily fell to the ground on exposure to the taser, with an average total time to incapacitation of 3 seconds. Further details of these studies are given in Chapter 2.4 of this report.

iii) Subject Population

Taser devices are effective against a high proportion of the population, including those who are drunk, or who are suffering from the effects of drugs or a mental illness. The taser, although painful, does not rely purely on pain compliance to gain control of the subject, thus resulting in the high level of effectiveness. It has been speculated that the effect is caused by the disruption of neuromuscular control that may also be accompanied by disruption of the neurophysiological feedback required for maintaining posture, leading to disturbances in posture and balance.

Despite this, some people will be capable of fighting through the effects of the electricity. A very small proportion of people are capable of resisting incapacitation even with the highest-powered tasers currently available. Higher-powered tasers are likely to affect a greater proportion of the population than lower-powered units[4], although the low powered tasers have been used thousands of times operationally in North America in the last twenty years or so, including many successful uses against drunk and drugged individuals. Hundreds of Police and other law enforcement officers, many in North America, have also experienced taser firings (usually by having the wires attached to their clothing as opposed to having the barbs fired at them - see Section 2.4 for more details).

Although a small proportion of people are capable of withstanding or fighting through the effects of the electricity, there are other more common reasons for the taser failing when used operationally. These are generally related to the taser unit, the cartridges, or insufficient training, rather than the ineffectiveness of the electricity and are detailed in Section 2.4.5.

Overall, international studies have shown the effectiveness of the taser to vary from 50% to a reported 100% when used in probe mode (cartridge discharged at the subject a distance away), touch-stun mode (the taser terminals pressed into the subject's body at close quarters) or as a deterrent. Section 2.4 of this report gives a more detailed summary of the reported effectiveness and failures of tasers used operationally and against volunteers in each of these modes.

iv) After-Effects and Injuries

The most intense effects of the taser only last for the duration that the electricity is applied, although the subject may feel dazed and lethargic for a short period afterwards and their muscles may be aching or tingling. In addition to the after-effects that may result from the high voltage electricity that has travelled through the subject's body, injuries can also be caused by:

- The taser barb penetrating the subjects skin

Each taser probe ends in an approximately 9mm long barb. These are capable of penetrating the skin when fired at a subject, although this may not occur in every case as the barb often attaches onto the subjects clothing. Injuries caused by the taser barbs penetrating the skin are usually minor. There is likely to be a small puncture wound accompanied by a slight redness of the skin around the wound, said to be similar to a bee sting, caused by the electrical current of the taser. More serious injury could occur if the barbs were to strike a sensitive area, such as the face, eyes or genitals.

If the taser barbs penetrate the skin, they need to be safely removed afterwards. Police departments throughout the United States have different policies on the removal of barbs. Common practice requires medical personnel to assess the extent of any injury caused by the barbs. Any barbs that have struck a sensitive area (e.g. face, neck, and groin) may require to be removed by medical personnel either on-site or at a medical facility. A number of departments allow police officers to remove barbs from non-sensitive areas, others require that medical personnel remove all barbs.

- Blunt trauma secondary injuries

These could be caused by the tasered person falling after being subjected to the electricity. Other injuries may also result if they fall onto a dangerous material such as glass or a noxious substance, or if the subject is near the edge of a high building or other place where a fall could result in a more serious injury.

- Other injuries

These could include injury to the eye caused by the projected laser sight from the taser being directed into the eye. Injuries could also result due to ignition of a subject who is tasered whilst they have a flammable liquid on them or if they are in a flammable environment.

Taser manufacturers issue safety notices with their taser devices. Typical recommendations include:

- Do not taser anyone on a ledge, rooftop edge, elevator shaft or other area where a fatal fall is likely to occur.
- Never aim at the head or neck of a subject.
- Do not use the taser near flammable or explosive liquids or fumes.
- Do not use the taser on the following groups of people:

- Anyone with a dysfunctional heart
- Anyone connected to oxygen tanks or other life support systems
- Pregnant women
- Small children

- Do not fire the taser where temporary incapacitation could prove dangerous e.g. at someone who is swimming.

Tasers have been associated with a number of deaths in the United States, however in most of these cases it was judged by the coroner that the actual cause of death was likely to be drug misuse[6].

Section 2.4 provides details of some American and Canadian studies on the operational use of tasers. In the Seattle police study of 108 incidents involving tasers[7], it was found that in 68% of incidents subjects sustained either no injury or only puncture abrasions from the taser barbs. 13% of subjects suffered injuries subsequent to taser use; these were secondary injuries generally due to the subject falling as a result of being tasered. No major subject injuries occurred and no injuries were attributed directly to the taser itself. The other 19% of subjects suffered injuries that were unrelated to the use of the tasers and a further two cases involved the subject being shot by the police.

The section of this report prepared by the Defence Science and Technology Laboratory (Dstl) provides more information on any after-effects and injuries relating to the use of tasers.

v) Unintended Effects to Operator

The taser uses high voltage electricity (tens of thousands of volts), which obviously has the potential to create a hazard. If used correctly and with proper training, the chance of the operator receiving an unintentional effect from the device will be kept to a minimum. However, given the high stress situations in which these devices are likely to be used, there is the potential for the operator or their colleagues to become wholly or partially affected by the electrical discharge. This could happen for a number of reasons, such as:

- The operator placing their fingers in front of the cartridge when firing, or inserting the cartridge with their fingers over the front while the weapon is unsafe and could potentially discharge;
- The officer touching the wires of the circuit when it is live;
- The weapon accidentally discharging;
- Use in a wet environment, as described in section 2.2.5;
- The officer placing themselves between the barbs of the taser while electricity is flowing through the circuit;
- If the resistance between the barbs is too high (as occurs when one barb fails to attach) the electricity will arc from one wire to the other, or between the electrodes on the front of the taser unit. At these times, the presence of arcing so close to the officer presents a hazard.

While it is impossible to account for every situation or possibility, it is important to be aware of what could happen. Good training and a knowledge of the way electricity flows should avoid most of these accidental shocks to the officer occurring.

During the PSDB police handling trials of tasers (see Section 2.3), 10 participants out of the 64 that attended reported receiving an electric shock through their fingers while using the tasers, although none reported experiencing the full effects.

2.2.4 Ease of Operation

The taser is a small, hand-held unit that is designed to be used by one officer only and should be suitable for the majority of officers to use. The taser is generally operated by either pulling a trigger or pressing a button on the device. The ease of operation of the taser depends on the particular model being used since different models have different handling characteristics and some units are more difficult to operate than others. Generally, the less actions required during operation of the device, the easier it will be to operate. Some models are also rather big and bulky and others require a lot of pressure to activate the trigger, which can be a particular problem for officers with smaller hands.

With some models of taser, the laser sights are activated when the weapon is made 'live' (i.e. the safety is turned off). This projected laser sight is then continuous until the weapon is again made safe. With other models, a separate action is required to activate the laser sights. Once activated, the operator must keep their finger on the laser activation button otherwise the laser sights are turned off. Additionally, some models provide a continuous timed burst of electricity when the trigger/button is activated, while for others the operator must keep their finger on the button/trigger to allow the electricity to flow as releasing this button will stop all discharge of electricity. This can be a particular problem as many officers may automatically take their finger off the trigger as soon as the barbs are ejected, although it should be possible to address this in training.

i) Repeat Operation – Speed of Multiple Use

As both barbs need to strike the target in order for a taser to be effective, multiple shots may be necessary as one or both barbs may miss the target. Section 2.3.5 details the proportion of shots that resulted in one or both barbs missing the target during the taser handling trials. This has also been known to be a cause of failure for taser devices when used operationally.

Some models of taser have dual-shot capability, meaning that a second cartridge can be fired immediately after the first cartridge without the need to reload. Other taser models have only single shot capability and the cartridge needs to be replaced if a subsequent shot is needed. Different models of taser use different cartridges and the design of the taser and cartridge can affect how quickly and easily the taser can be loaded and unloaded, in full light and in darkness.

As mentioned previously, it is possible with all models of taser to reapply charge to the subject after the initial discharge has ended, providing both barbs are still attached to the person. If one or both barbs have become detached from the target, then a new cartridge will have to be fired unless the devices are to be used in touch-stun mode.

2.2.5 Environment

i) Enclosed Spaces

Tasers are small, hand held devices that are relatively easy to handle and so may be suitable for using indoors or where space is limited, providing there is an unobstructed path for both barbs. There are no rebound effects from the barbs and, although there are no major contamination problems, the unpleasant smell and smoke from cartridges that use rifle primer as a propellant may build up. Tasers can also be used relatively close to the subject, although closer distances will result in less barb separation and therefore less muscle groups being affected, which can limit their effectiveness. The ease of operation of the different models of taser will affect how well each can be used in a confined space.

ii) Low Light

The suitability of tasers for use in the dark or under low light conditions will vary depending on which model is used as this affects their ease of handling. The design of the cartridges and cartridge housing will also have an effect on how easy the taser is to load and unload under these conditions. For instance, if a cartridge can only be inserted into the taser in one particular orientation, this is likely to be more difficult

to load in the dark than a cartridge that can be inserted in a number of orientations. Use of tasers in a dark environment was assessed at the taser handling trials (see Section 2.3). The results indicated that, providing an officer is confident in the handling and use of a particular model of taser, they should be able to use the taser under low lighting conditions.

iii) Temperature

Tests were carried out at PSDB to evaluate any adverse effects caused when the tasers were subjected to temperatures of –20ºC and +50ºC. At the higher temperature most of the taser models performed as normal, although one unit was incapable of firing at this temperature and the laser sights and battery indicator did not work. These problems were due to the taser unit itself, and not the batteries or cartridges as these were found to perform as normal.

At –20ºC most taser models were adversely affected. The units became difficult to fire and the laser sights generally became diffuse, fragmented or dim. The power output was also greatly reduced due to the effect that the temperature had on the batteries. This effect was most severe with alkaline batteries, although rechargeable batteries were also adversely affected. The models that used lithium batteries were unaffected by this low temperature.

iv) Wet Environment

If tasers are used in a wet environment, it is possible that the presence of water could affect the way the electricity flows. The conductivity of water varies depending on its purity; increasing purity results in decreasing conductivity. Impure water will therefore conduct electricity better than air, and its presence may provide an easier path for the electricity to take in some situations. In general, if a person is standing in a pool of water and both barbs are attached to their body or clothing, the water should have no effect and the current will flow through the subject as normal. If the subjects' clothes are soaked in water and both barbs are attached to their body or clothing, then there may be some reduced effectiveness of the taser as some of the electricity could pass through the clothing on the outside of the body, rather than it all passing through the subject's body.

These are just examples to illustrate the increasing uncertainty that exists in such an environment and to highlight some of the possible effects. The effects of the electricity in a wet environment have not been tested by PSDB. It is impossible to advise on what could happen in every situation, however it is important to realise how the electricity travels in order to try to work out what is likely to happen in a particular situation.

v) Flammable Environment

If a taser discharge is applied to a subject who has a flammable liquid on them, such as petrol or strong alcohol, there is a chance that the solvent will catch fire and the subject and their clothing may be engulfed in flames. This is also a potential problem if the subject has already been sprayed with a police incapacitant spray (CS or PAVA) as the solvents currently used in these are flammable (methyl isobutyl ketone – MIBK - and 1:1 ethanol:water respectively). Flammable environments, such as petrol stations, may also present a potential hazard. This has already happened on at least 2 occasions when tasers have been used operationally in other countries, when the taser has ignited subjects who were soaked in a flammable liquid.

vi) Electrical Equipment

As tasers arc, they produce large electro-magnetic fields and it is possible that some types of electrical equipment may be affected by their use. Such effects have occurred during testing of the tasers when, for instance, the firing of a taser has caused computer monitors to show lines on the screens, the programmable keyboard on a PC to lock occasionally, a calculator to switch itself on and a digital stopwatch to start and stop. This may be important operationally as there is a possibility that the fields could interfere with communications equipment, hospital equipment and other electrical devices.

A recent study carried out by the Information and Communication Technology Unit[8] of the Home Office has found that there is no interference of tasers with Airwave TETRA communication devices and that the TETRA terminals will not set off the tasers accidentally. The same test also found that tasers did not interfere with the liquid crystal displays (LCD's) on the equipment. However, if tasers are introduced into the police service, testing with other items of police electrical equipment may be required if the taser is likely to be used in close proximity to them.

2.2.6 Durability

The manufacturers of tasers are responsible for ensuring that the equipment produced is fit for purpose. They will offer a warranty on their products and suitable arrangements should be in place before purchasing equipment to ensure that any damaged or faulty equipment can be exchanged or replaced as necessary.

A taser device is generally made of plastic containing the electronic circuitry, batteries and connections. The laser sight, when present, is either an integral part of the unit or is connected to the top or side of the unit. In addition to this, a cartridge containing a primer, two lengths of coiled wire and two barbs, is also connected onto the unit. As such, there are many parts of the unit that could break during carriage and use depending on the conditions in which they are used.

PSDB carried out drop tests on the various taser models. This involved dropping the units and cartridges from a height of 2m onto a steel plate. Under such conditions, various types of damage occurred to the units when they were dropped, varying from the battery catch being released to the laser sights smashing or breaking off, or the taser subsequently ceasing to fire. The cartridges often dropped out of the taser unit and damage often occurred to the cartridges themselves when these were dropped. The damage to the cartridges tended to involve the barbs dropping out of the casing and the wires unravelling. In this case, the fault is obvious and should not result in a faulty cartridge being used operationally.

Throughout PSDB's evaluation of taser devices, including the handling trials, a number of problems became evident with some of the models tested. These problems included incompatibility of cartridges and taser units, faulty cartridges, sights and batteries, and unreliable taser units. In general, the problems encountered tended to suggest that the companies had either not tested all of their products and related equipment thoroughly enough, or did not have a sufficiently rigorous quality control procedure in place, particularly when they used parts that had been made by a contracted agency.

2.2.7 Security and Licensing

The taser is classified as a Prohibited Weapon under Section 5 (1) (b) of the Firearms Act 1968 and the acquisition and possession of these devices must be in accordance with this. Police forces or registered firearms dealers also need an import licence from the Department of Trade and Industry to import the units into the UK. As mentioned previously, there is currently a ban on the export of electroshock devices, including tasers, from the UK. This means that although forces would be able to import the devices, they may be unable to export them out of the country again, for instance to return a faulty weapon to the US manufacturer for repair.

Given the nature of these devices, due consideration should also be given to their safe and secure storage. The tasers should be stored at room temperature to avoid any adverse effects caused by extremes of heat or cold.

i) Audit Trail

Many taser units have unique serial numbers printed on them, either on a sticker or built in as an integral part of the unit. Additionally, one model of taser has a data recording system, which stores the date and time of previous firings of the taser. Any repeat firing will be stored as a new entry and use in stun mode

is also recorded, as is a practice or warning firing. This data can then be downloaded to a compatible computer, which will display all of this information.

Some types of taser cartridges have a unique serial number attached to them. Additionally, some types of cartridge come with unique, small, confetti-like identification tags that are ejected when the cartridge is fired and scatter around the area nearby. Each tag has the serial number of the cartridge that has been fired printed on it.

Obviously, for any audit trail to be effective, it needs to be backed up by a suitable logging system within the force to record which officers have been issued with which tasers and cartridges.

2.2.8 Training

Training in the use of tasers tends to be offered at three different levels; operator training, instructor training and training for officers that train the instructors. The courses offered by the manufacturers generally last 4-16 hours, depending on the level of training required, and re-certification is usually required every 1-2 years. The courses involve a practical and a written test, with a minimum performance standard being required of the officers before they can pass.

The courses tend to involve training in the following areas:

- Firing and aiming of tasers
- Loading and unloading
- Safety checks
- Batteries and taser maintenance
- Barb placement and barb trajectory
- Practical firing exercises
- Barb removal
- Understanding of taser physiology
- Use of force
- Legal standards
- Specifications and operation of currently available taser models
- Different cartridge types
- Causes of taser failure

This training package is recommended by the US manufacturers of the taser devices. This may change when considering the use of tasers in the UK context and ACPO guidelines for training and re-certification periods may also differ. Similarly, the legal aspects of the courses are obviously presented from a U.S. viewpoint and would have to be reviewed when training British police officers.

In the taser handling trials, the participants were given a 2-3 hour ‘familiarisation’ session with the tasers. This involved them being briefed on the various models and how to handle and use them safely and correctly, then firing one cartridge from each of the four models of taser. Each participant then fired 3-6 shots from each taser model throughout the various exercises. Following the handling trials, questionnaires were issued asking how confident they felt about using the devices after they had handled them during the preceding familiarisation training and exercises. The officer’s confidence in handling the various weapons varied substantially depending on the particular model being assessed, with almost all officers feeling confident in the handling and use of one particular model and less than half being confident with the use of another model.

Tasers will not have any rebound effect or contamination problems, therefore indoor facilities should be suitable for training. If cartridges using rifle primer as the propellant are fired, however, a build-up of unpleasant smelling smoke can occur and suitable ventilation will be required. Safety precautions must be in place during training to avoid officers being accidentally exposed to electricity, barbs or the laser beam.

2.2.9 Costs

The average cost of a taser unit, including laser sights, is between £300 and £500. Each cartridge costs around £15. Other costs associated with the equipment include batteries and chargers, holsters, training aids, software (if necessary) and any additional optional extras, specific to particular models of taser. These prices are obviously subject to change at the discretion of the manufacturer.

2.2.10 Acceptability and Visual Effect

The issue of acceptability is a matter for the Home Office, the NIO and ACPO, although it is appropriate to mention it briefly here. Amnesty International has often expressed concerns about electrical devices (termed 'electro-shock weapons' by them) as they do not believe that sufficient health and safety data are currently available with regards to the effects of this type of device on the human body. They have asked that *'the stun belt should be immediately banned and the use of other electro-shock weapons such as stun guns, stun shields, and tasers should be suspended pending the outcome of a rigorous, independent and impartial inquiry into the use and effects of the equipment'*. This concern is being addressed by the contracting of Dstl to carry out a full and independent assessment of the medical implications of the use of tasers. The detailed study that PSDB has carried out on taser devices should also answer many of the technical questions that people have about them and any decisions made about their use will be based partly on the information that PSDB has gathered along with the outcome of Dstl's assessments.

Amnesty International are also concerned about the exportation of electrical devices to countries that may use them as a method of torture. Electrical devices have been used as a means of torture in a number of countries due to their ability to inflict extreme pain with little or no noticeable injury afterwards, and therefore potentially providing no evidence of their use. Amnesty International has therefore called for a ban on exports to any country where electro-shock torture has been committed or where torture is persistently reported. As mentioned previously, the UK has already banned the export or transhipment of a number of electrical devices from the UK, including electric batons, shields, stun guns and tasers. In addition, the presence of a dataport on one model of taser, which records the date and time of previous taser firings, will provide evidence that the taser unit has been used.

Different models of taser have different shapes and sizes. Some models are shaped like firearms whilst others more closely resemble a flashlight or torch (see Section 2.1). Often, the firearm-shaped models can be altered to allow them to be differentiated from actual firearms by, for instance, being manufactured in a colour other than the standard black (such as red or yellow) or having coloured stickers to attach to the side of the unit. While this should help identify the weapon as being less lethal, problems may still exist in very dark conditions. In addition, using a firearms-shaped taser (and indeed any other firearm-shaped less lethal device) may make the subject believe they are been targeted with a lethal weapon, which may result in them responding in a lethal manner. There may also be an adverse reaction from the public if police were to carry a firearm-shaped weapon. Despite these problems, it may be an advantage for the taser to be shaped in this way as it may allow better handling and easier operation of the device.

2.2.11 Electrical Output

A series of tests were carried out at PSDB to determine the electrical output of all the available taser models in terms of waveform, current, voltage, pulse-width, energy and power. Measurements were also made of any changes which occurred to these when an air gap was incorporated into the circuit (as

would be the case if a barb did not penetrate the skin of the target but instead attached onto their clothing). These tests were necessary not only to give PSDB a fuller understanding of a taser's output, but also to provide information to Dstl to help them assess the effects of the taser on the human body. The following is a summary of the tests and broad conclusions that can be drawn from the results. The full details of the tests will be published separately.

A circuit was set up to measure the peak voltage across, and peak current passing through, the body (Figure 7). The circuit consisted of a potential divider connected between the barbs of the taser. Since the resistance of the body can vary, the taser output measurements were obtained for a wide range of resistances. In this experiment the total value of the potential divider ranged from approximately 47 to 4700 Ohms as these were the boundary values used in a similar, previous study[9].

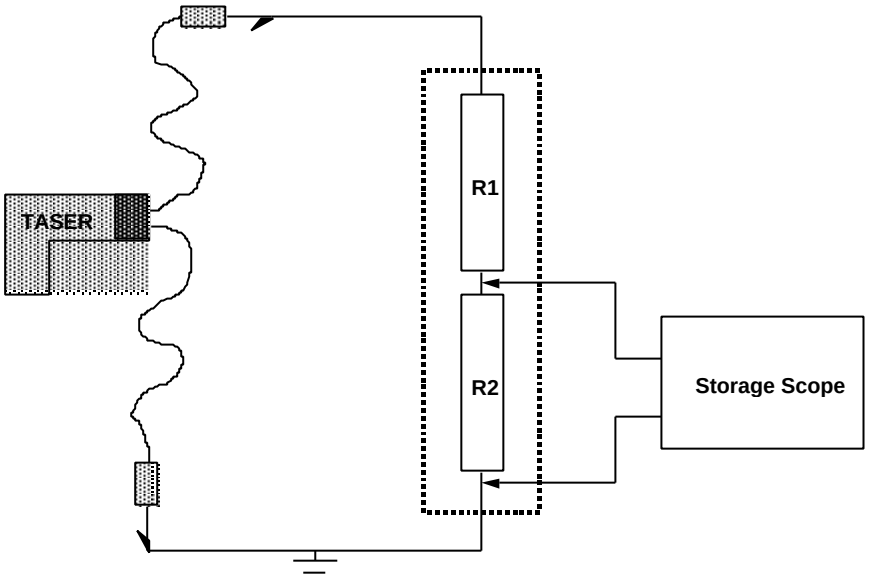

FIGURE 7: ***Circuit Used to Measure Peak Voltages and Peak Currents from the Taser that are Experienced by the Body.***

Figure 8 shows an example of the output as seen on the oscilloscope and demonstrates several features that are common to the outputs of all makes and models of taser. This trace represents one whole 'click' or pulse of the taser. The initial spike is the high voltage point of extremely short duration at the start of the pulse. This can vary in size and width and appears to be the only part of the wave affected by the introduction of an air gap into the circuit. All models also have the subsequent small "spikes" and the period of "noise" seen at the end of the signal.

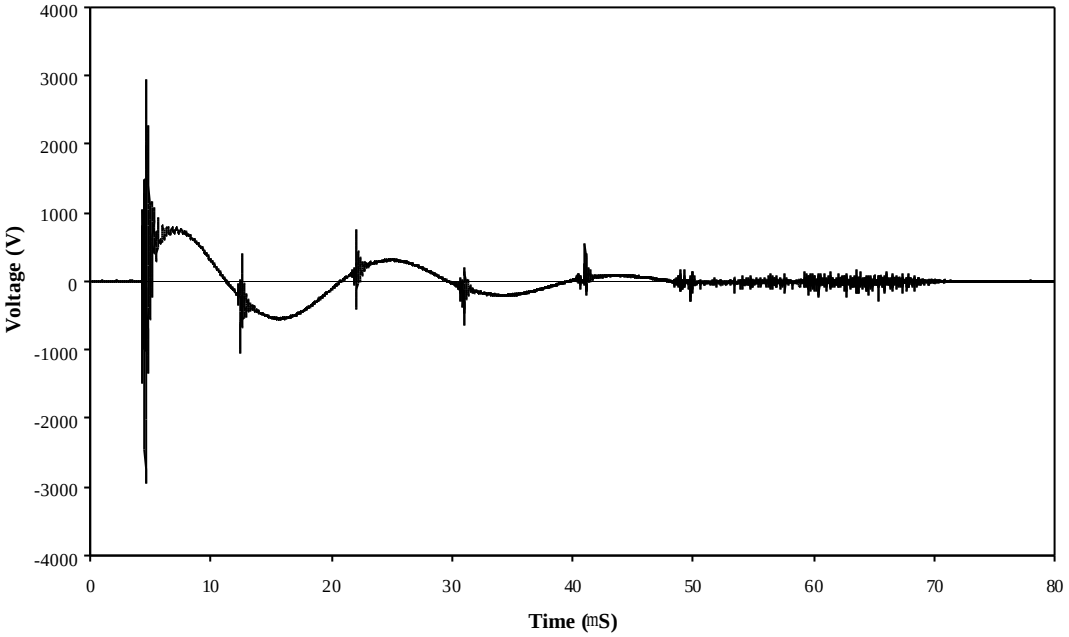

FIGURE 8: ***Graph of the Actual Taser Output as Recorded by the Oscilloscope for a Total Resistance of 47W, Showing the Variation in Voltage Over Time for One 'Click' of the Taser.***

It was found that the voltage produced by the tasers increased with resistance and different taser models have different voltages and different power outputs.

An air gap was also introduced into the circuit to determine how far a barb could be from the body before the taser would lose its effect. Electricity in this case can overcome the resistance of the air and 'arc' across the air gap unless the size of the air gap is too great. The test took as its criterion the distance at which 50% of the pulses from the taser would not arc across the gap. The maximum effective separation was found to be 25mm and 35mm in two different models of taser. It should be noted that clothing materials would have resistances different to that of air so the thickness of clothing that would have the same effect may vary.

2.3 Taser Handling Trials

2.3.1 Introduction

In March 2002 PSDB held a three-day series of trials at its Langhurst facility in Sussex. The purpose of these trials was to assess the handling characteristics of different taser devices when fired by police officers in a range of situations. A number of exercises were devised to allow an assessment of the realistic performance achievable from tasers in general, and to allow a comparison to be made between the different models. A questionnaire was distributed to participating police officers to establish their views on each of the tasers used in the trials.

The trials involved the use of four different models of taser, these were labelled as A, B, C or D throughout. As explained earlier, specific results for the different models of taser evaluated cannot be detailed here for reasons of commercial confidentiality.

2.3.2 Participating Officers

59 police officers from 20 different police forces in England and Wales and 5 prison officers participated in the trials. Each force participating in the trials was asked to nominate three officers, from a selection of officer groups. The officer groups were general patrol officers, firearms trained officers, public order trained officers, CID officers, and covert/undercover officers. It was also specified that each officer nominated should represent a different length of service band, 0-5 years, 5-10 years, 10-15 years, 15-20 years, 20-25 years or 25-30 years. Each force was asked to provide one female officer (twenty-one female officers participated in the trials). A breakdown of the attending officers is given in Figures 9 and 10.

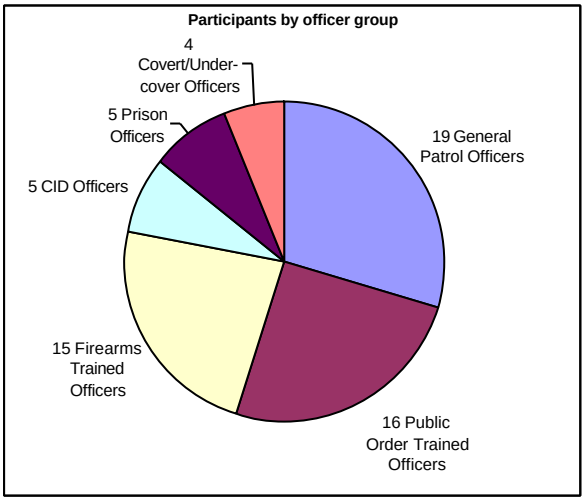

FIGURE 9: ***Participants by Officer Group***

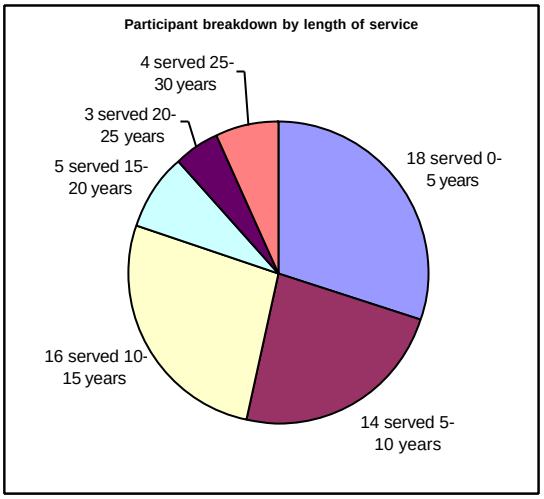

FIGURE 10: ***Participant Breakdown by Length of Service***

The numbers in Figure 10 do not include 4 prison officers for whom length of service details were not provided.

Each officer attended the trials for one morning or afternoon session and was given training in the use of the models of taser being used in the exercise. Training consisted of an introductory talk from a PSDB police advisor who had passed the manufacturer's training course followed by a practical introduction to the tasers, where officers were given the opportunity to fire one cartridge from each of the different models of taser.

After initial training, each officer took part in two exercises each of which involved firing 2 or 3 cartridges from each model of taser. After completion of the practical stages each officer was given a questionnaire for completion on the day of the trials.

2.3.3 Aim of Trials

The main aim of the trials was to assess the accuracy of the different models of taser when hand-fired by officers in a range of situations that might relate to those being faced operationally (note: these were not true scenario-based trials). The trials aimed to assess the performance of tasers as a whole and to identify important differences in the performance of the different models. The trials also aimed to address a number of other points regarding the operational performance of tasers, such as:

i) Ease of Operation: Is the option capable of being operated by one officer? Is it suitable for use by the majority of officers with appropriate training, regardless of physical size or gender? Does it rely on complex motor skills?

ii) Environment: Is the option effective in all operating conditions (e.g. weather, indoors/outdoors, lighting, temperature, etc.) and in confined spaces?

iii) Mobility/Flexibility: Is the option effective against a moving target? Can it be easily transported to the scene of an incident, and portable at the scene?

iv) 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)?

v) 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)?

vi) 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?

vii) 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?

Some of these points were addressed directly in the various handling exercises while others formed part of the questionnaire issued to participating officers.

2.3.4 Exercises

When firing the tasers the officers were instructed to aim at the upper torso with the sight for the upper barb such that both barbs should strike the body of the target. They were told to avoid the head and neck areas when firing. For each shot the position of the two barbs relative to the target were recorded as shown in Figure 11. The position of each barb was recorded as the section of the target into which it fell.

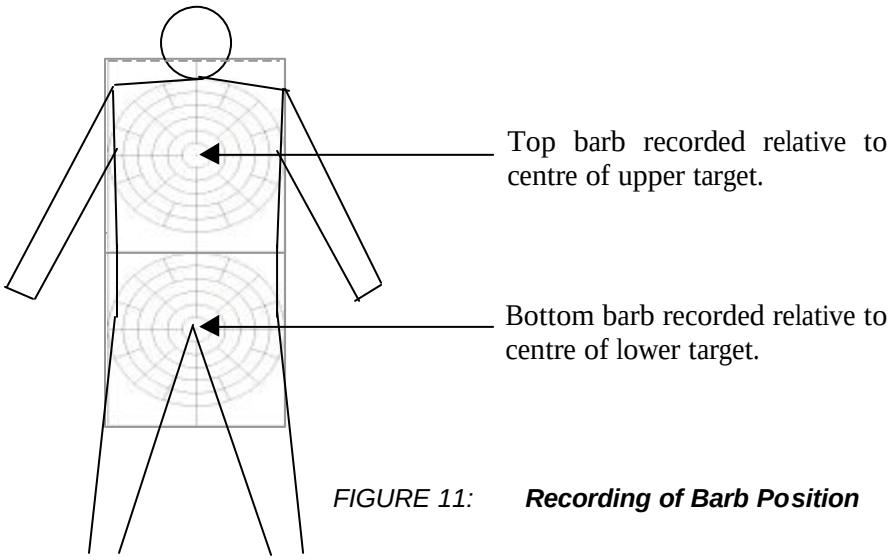

FIGURE 11: ***Recording of Barb Position***

Examples of results recorded on targets are shown in Figures 12-14 (note, the grids were not present on the targets during the trials, the officers saw only the outline of a figure). These illustrate example results for Exercise X using Taser Y. The numbers in each section marked on the target indicate the total number of times that a barb landed in that section during the trial. Black numbers represent the top barb and grey numbers represent the bottom barb. Although the position of some close misses is indicated (especially between the legs), where barbs were wide of the target they are recorded as a 'miss'.

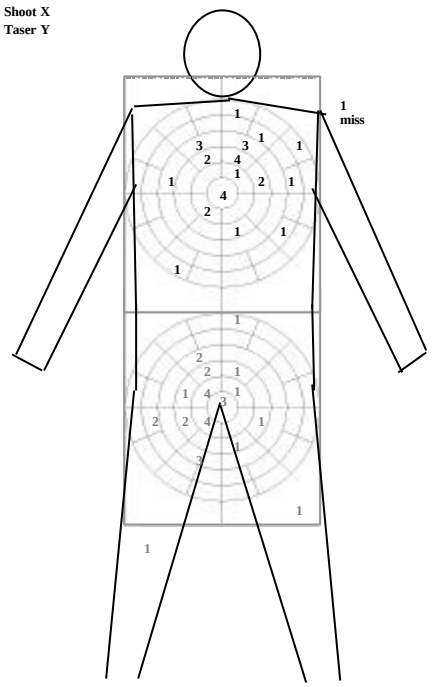

FIGURE 12: ***Example of Results Recorded on Front-Facing Target***

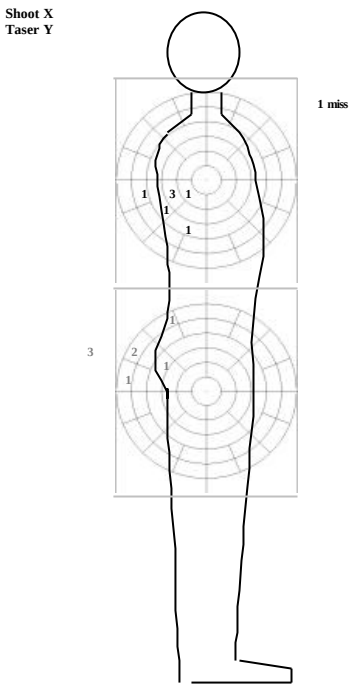

FIGURE 13: ***Example of Results Recorded on Profile Target***

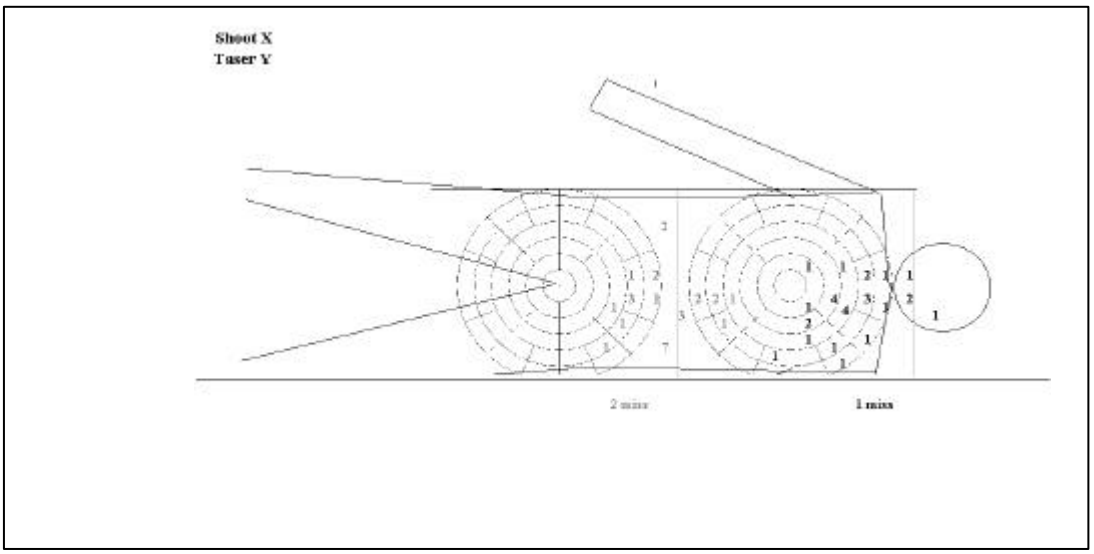

FIGURE 14: ***Example of Results Recorded on Prone Target***

For each shot it was recorded whether both barbs hit the target, both barbs missed the target or one barb missed. A successful shot required both barbs to strike the target. These results are represented in a bar chart as percentages as shown in Figure 15 (the percentage in each category is displayed on the relevant bar). Percentages have been used to facilitate the comparison of the results from the different exercises and between different tasers. However, it should be noted that different numbers of officers attempted each exercise (from 2 officers firing a total of 6 shots from each taser model for one exercise, up to 11 officers firing a total of 33 shots from each device for another exercise).

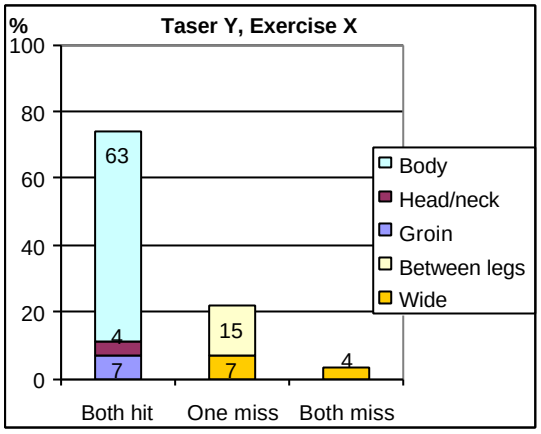

FIGURE 15: ***Example Hit-Miss Bar Chart***

When both barbs hit the target it was noted when either of the barbs hit the head/neck area, causing potential injury, or the groin area. The bottom target was centred on this as an easy reference point and not as the preferred point of aim.

When one barb missed the target it was noted if this was wide of the target or between the legs. When both barbs missed the target it was noted if either of these passed between the legs.

The distinction was made between a barb passing between the legs or going wide as it was felt that in many real situations this might result in a hit on the legs.

Officers were timed throughout the various exercises to determine how long they took to draw, load, aim and fire the devices. The results are represented in bar charts as shown in Figure 16.

Each bar represents the mean time taken to fire one shot for taser A (column 1), taser B (column 2), taser C (column 3) and taser D (column 4).

The vertical lines represent the range of times taken (minimum and maximum). Where the maximum time is considerably greater than the average it generally indicates one or two officers having particular problems with either loading or firing the device.

FIGURE 16: ***Example Time to Fire Bar Chart***

16 exercises in total were enacted throughout the trials, including stationary and moving targets and firers, side-profile, prone and front facing targets, full light and low light conditions, etc. A total of 1,253 cartridges were fired by officers throughout the exercises (this does not include those cartridges fired during training). The different exercises are summarised in Table 1.

Shoot #	Position of Firer	Position of Target	Lighting	Status of Taser	Laser Sights Used?	No. of Shots
1	Stationary, Upright	Stationary, Face on	ON	Loaded, In holster	YES	Single (3)
2	Stationary, Upright	Stationary, Face on	ON	Unloaded, In holster	YES	Single (3)
3	Stationary, Upright	Stationary, Face on	ON	Loaded, In holster	NO	Single (3)
4	Stationary, Upright	Stationary, Face on	OFF	Unloaded, In holster	YES	Single (3)
5	Stationary, Kneeling	Stationary, Face on	ON	Loaded, Drawn	YES	Single (3)
6	Upright, Moving Forward	Stationary, Face on	ON	Loaded, In holster	YES	Single (3)
7	Stationary, Upright	Stationary, Lying on Floor	ON	Loaded, In holster	YES	Single (3)
8	Stationary, Upright	Stationary, Face on	ON	Loaded, In holster	YES	Multiple (3)
9	Stationary, Upright	Stationary, Face on	ON	Unloaded, In holster	YES	Multiple (3)
10	Stationary, Upright	Side Profile, Moving at high speed for 170cm	ON	Loaded, Drawn	YES	Single (2)
11	Stationary, Upright	Stationary, Lying on Floor	ON	Loaded, In holster	NO	Single (3)
12	Stationary, Upright	Face on, Moving at slow speed for 85cm	ON	Loaded, Drawn	YES	Single (2)
13	Stationary, Upright	Stationary, Side Profile	ON	Loaded, In holster	YES	Single (3)
14	Shooting over 6ft barrier	Stationary, Face on	ON	Loaded, Drawn	YES	Single (2)
15	Shooting around 6ft barrier	Stationary, Face on	ON	Loaded, Drawn	YES	Single (2)
16	Stationary, Upright	Stationary, Face on	OFF	Unloaded, In holster	NO	Single (2)

TABLE 1: ***Summary of Exercises from Taser Handling Trials***

2.3.5 Results

Figure 17 summarises the barb placement for all 1,253 cartridges fired throughout the taser handling trials*. The graph shows the overall distribution of the barbs on the body for all of the exercises combined. These exercises involved stationary and moving targets; light and dark conditions; with and without the laser sights on the taser; upright and prone target; operator standing, kneeling and walking; full body and side profile of target. The results are combined for all participants and for all models of taser. All exercises were carried out at a distance of 13ft (4.0m) between the operator and the target.

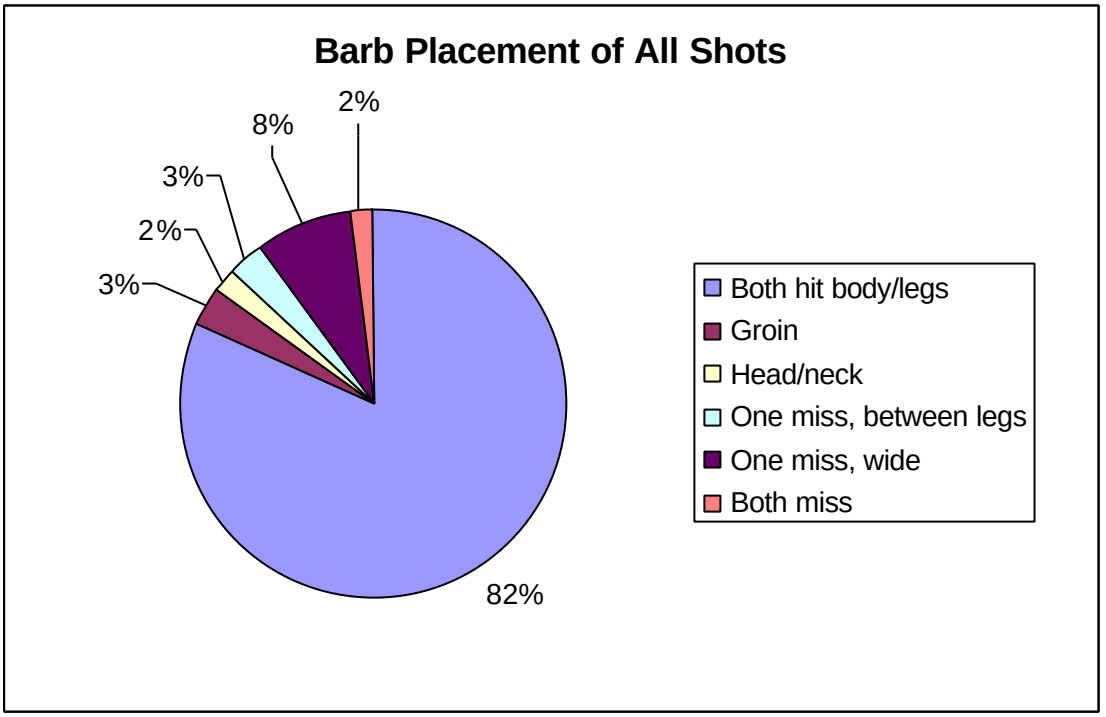

FIGURE 17: ***Distribution of Taser Barbs for All Cartridges Fired in Taser Handling Trials***

Figure 17 illustrates that, for all the exercises combined:

- 82% of shots resulted in both barbs hitting the body of the target, but not hitting the head, neck or groin region;
- 5% of shots resulted in one barb hitting the groin, head or neck area of the body;
- 13% of shots resulted in one or both barbs missing the body and landing either between the legs or wide of the body.

A lot of other useful information has been gained from these trials, relating to the capabilities of tasers in general and the variation in performance of the different models. Much of this information has been used to complete Section 2.2 of this report and to provide more specific information to the police service.

2.3.6 Questionnaires

The participants completed a questionnaire after they had been trained in the use of each taser and had taken part in two exercises. The questionnaire consisted of 17 questions. A statement was given and the participants were asked to indicate for each of the different models whether they strongly agreed, tended to agree, tended to disagree or strongly disagreed with each statement or to indicate a "don't know"

* The officers involved in the handling trials were given a 2-3 hour familiarisation session with the tasers, which included some 1-1 tuition. During the familiarisation session they were informed about the different models and allowed to fire one cartridge from each model before beginning the various exercises. This is likely to differ from the amount of training that an officer would be given before using the device operationally.

response. The final two questions asked the participants to select the taser model they liked/disliked most. Space was also left for comments to be recorded for each question.

Figure 18 provides an example of the responses to one of the questions in the questionnaire.

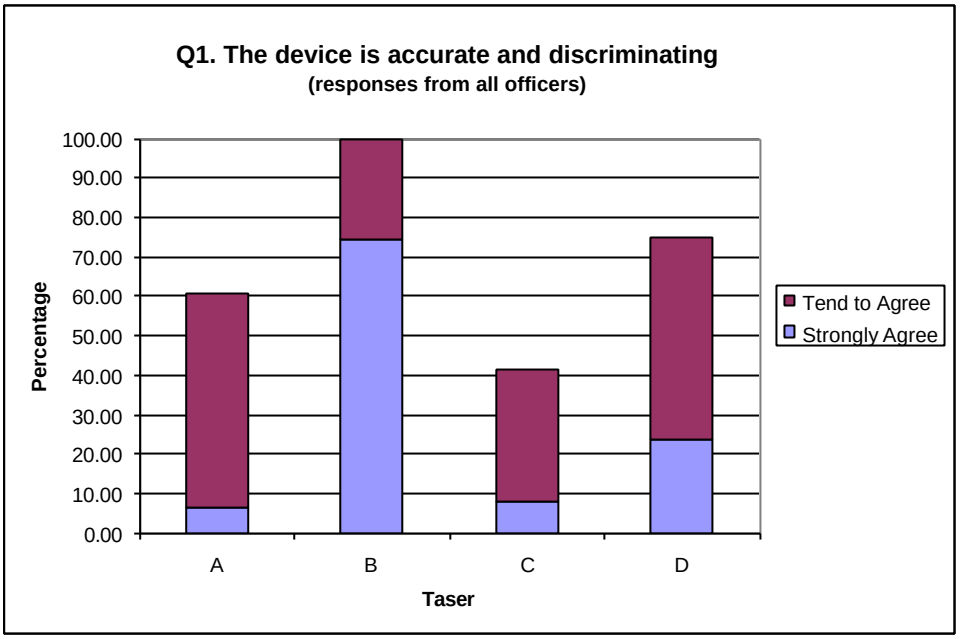

FIGURE 18: ***Responses From All Officers to Question 1***

2.3.7 Conclusions

The trials were not intended to cover every possible operational scenario in which tasers could be used, instead the exercises focussed on a number of key areas.

The training provided at these handling trials was short and a number of issues arising during the trials, such as speed of reloading or aiming without laser sights, could be resolved with a more extensive training programme.

For questions involving unusual conditions, such as low lighting or moving targets, the officers who participated in the related exercises reported more favourably on the use of tasers compared to the other officers.

Throughout the handling trials the variation in the handling characteristics of the different models of taser became obvious. This affected the accuracy of the devices as well as the responses that the officers recorded in the questionnaires.

2.4 International Taser Use

This section describes the use of tasers internationally. Information has been gathered from a range of sources including manufacturers, police forces and corrections agencies in the United States and Canada, and from the press.

Taser manufacturers claim to be supplying tasers to over 1000 law enforcement agencies in the United States and Canada. It should be noted that there are more than 18,000 law enforcement agencies in the United States alone, 75% of these agencies have less than 50 officers. Many correctional agencies also use taser devices.

Two American airlines have also been reported in the press as purchasing tasers for use on its aircraft - United Airlines and Mesa Air. The airlines have not yet deployed tasers on their aircraft as they are still

awaiting a decision from the Federal Aviation Authority as to the safety and legality of using the weapons in aircraft.

PSDB requested information from law enforcement and corrections agencies on the use of tasers in their force/department. Specific information was requested on what devices were used, how many are held by the department, which officers they are issued to, rate of use, success rate, details of any associated injuries or deaths and use of other electrical devices or less lethal technologies.

This section provides information on the use of taser devices by a number of police forces and correctional facilities in the US and Canada. Three case studies are also presented which provide information on the evaluation, introduction and use of taser devices by three separate police forces. The figures that are given for effectiveness, mode of use, types of incidents, etc. are those presented within the study reports and may not always add up to exactly 100%. Each force also presented different types of information in their study reports, so it is not always possible to compare aspects directly between the different forces. In addition, the forces have different ways of defining whether the use of the taser has been "effective", which makes it difficult to compare results directly.

2.4.1 Victoria Police Department, Canada

In December 1998, the Victoria Police Department in Canada became the first Canadian police force to use taser devices. They carried out a six-month field study with the Tasertron TE95 model of taser[3]. The main outcomes from this study are listed below:

- The taser was deployed 14 times in total. Nine incidents involved the barbs being fired at the subject, while in the other five incidents the use of the laser sights alone was sufficient to induce compliance in the subject;
- Of the nine incidents where the barbs were fired at the subject, four resulted in both barbs penetrating the skin, two involved one barb penetrating the skin and the other three involved the barbs penetrating the subject's clothing only;
- In one incident, the use of the taser was ineffective as the bottom barb missed the subject;
- On average, the taser took between 3-5 seconds to control the subject, although in one case it took as long as 15 seconds;
- In six of the nine incidents where taser barbs were fired, only one application of the taser was required. In the other three incidents, the subject attempted to physically resist the officers following the first application and a second application was required to gain compliance. None of the incidents required more than two applications of the taser and no incident involved the discharge of more than one cartridge;
- In several of the incidents, the police agency said that if the taser was not available the subject would have either killed themselves, or the officer would have had to resort to deadly force against the subject.

Victoria Police Department carried out a further study comparing the newer higher-powered TE95HP model from Tasertron with the lower powered TE95 model[4]. Comparisons were also made with the Taser International M26 model, which the force has now started to use.

2.4.2 Royal Canadian Mounted Police (RCMP), Canada

Information restricted at the present time.

2.4.3 Seattle Police Department, USA

Following the fatal shooting of a mentally ill man by Seattle police in April 2000, the Seattle Police Department began looking at how they could expand the availability of less lethal options for patrol officers. An internal study group was specifically set up within the force to look at this. The two less lethal options that they recommended were the M26 taser and a shotgun with 12 gauge sock rounds[7].

By the end of 2001, 158 M26 tasers had been issued to officers. 136 of these were deployed in patrol units, 14 in special units and 8 in SWAT vehicles. A 13-month field study using the M26 tasers was carried out from 1st January 2001 to 31st January 2002. In nearly 60% of incidents, the taser officer was among the first responding officers to the scene. The key points from this study are given below:

- A total of 108 incidents took place in which the M26 was used. Two of these resulted in the fatal shooting of the subjects by police officers;
- Tasers were used in the probe mode (i.e. barbs fired at the subject) about 60% of the time, in the stun mode 27% of the time and both modes were used 12% of the time;
- Verified taser contact was made with the subject in 86% of all incidents. Of these, a disabling or partially disabling effect was achieved 95% of the time;
- In 85% of all incidents and in 92% of the incidents where contact was verified, the taser was credited with controlling the subject or bringing the situation to a resolution;
- 59% of tasered subjects were impaired, often severely, by alcohol, drugs, or a mental illness or delusion;
- A quarter of the subjects were armed, most often with knives (15% of the armed offenders were armed with guns);
- Injuries to the subjects subsequent to taser use occurred in 13% of the incidents. These were generally caused by the subject hitting the ground when being tasered. No injuries were major and none were attributed directly to the taser itself;
- In 5% of incidents, there were officer injuries after taser deployment or directly related to its use. All injuries were minor.

2.4.4 Other Agencies

A number of other police agencies and correctional facilities provided limited information on their deployment and use of tasers. In terms of their deployment, tasers are generally issued to field patrol supervisors or carried in patrol cars in smaller police departments, with further units stored for use in detention facilities or for use in prisoner transportation. A number of larger departments are moving towards issuing a taser to all officers. In prison facilities the tasers are either carried by supervisors or held in a central location for use in incidents or for movement of high-risk prisoners.

The corrections departments contacted indicated that tasers were often used in conjunction with other forms of electrical device, such as hand held touch stun devices and electrified shields. A number of police departments also indicated that they used hand held stun devices in addition to the touch-stun features of the taser.

i) Effectiveness Data

Sample data from a number of law enforcement agencies is given in Table 2. The data includes effectiveness information when the taser is used in barb mode and touch-stun mode. For some departments, separate information was not given for each mode of use.

Department	Model	Rate of Use	Effectiveness Probe Mode (%)	Effectiveness Stun Mode (%)
Police Department in California	M26 (previously used Tasertron 7W tasers)	5 in 4 months	100%	Less effective than barbs
Police Department in California	M26	-	100% On two occasions required a second shock from the same cartridge	-
Police Department in Arizona	M26	15 times / month	100%	50%
Sheriff's Department in South Carolina	TE95HP	-	100% 90% for detention centre staff	-
Sheriff's Department in California	M26	24 times in 4 months	92%	-
Prison Department in Nevada	TE95	Deployed once every 10 days, used once every 15-20 deployments.	95%	-
Sheriff's Department in Iowa	TE95HP	-	90% +	-
RCMP, Canada	M26	139 in 10 months	78%	89%
Police Department in California	M26	24 times in 9 months	79%	70%
Seattle Police Department, USA	M26	108 in 13 months	85% overall, 95% where probes struck target	-
Police Department in Louisiana	TE95HP	6-10 times / year	100% (when using 2 cartridges)	-
Victoria Police Department, Canada	TE95	14 in 6 months, including 5 without discharge	93% overall, 89% when barbs fired	-

TABLE 2: ***Effectiveness of Taser Devices***

It is difficult to compare these results directly as different agencies have different ways of recording an 'effective' use. For instance some agencies will record a failure every time a barb misses the target, whereas another agency will look at the overall result, regardless of how many cartridges needed to be fired or bursts of electricity were needed. Effectiveness rates may also include uses of the taser that did not involve firing a cartridge. A number of police departments reported that the laser sights were often an effective deterrent in themselves. Additionally, sparking of the taser to indicate the imminent use of an electrical device can also prove effective.

As an example, the Prison Department in Nevada noted that tasers are deployed once every 10 days with an effectiveness of 95%. Although tasers are deployed every 10 days, they are actually only fired once in every 15-20 deployments (i.e. approximately once every 6 months). When the taser is demonstrated by a spark test the majority of prisoners become compliant rather than have the taser used against them. The taser is used as a "show of force" reducing the need for actual force to be used in many situations. These figures are for maximum-security institutions, in lower-security prisons the tasers are rarely used except as a show of force.

Where the taser has been ineffective this is often due to failure of one or both barbs to strike the target rather than failure of the electrical discharge to incapacitate the subject. Possible reasons for failure are discussed below. Operationally, there have been incidents where individuals have not been fully incapacitated by the electricity and have recovered immediately after the current has ceased.

Effectiveness ratings in touch-stun mode vary more widely than those quoted for barb mode. When tasers are used in touch stun mode they do not have the same electrical effect on the body. The electricity will only act over a small area when used in touch-stun mode, causing pain and debilitation rather than complete incapacitation.

2.4.5 Reasons for Ineffectiveness

There are a number of reasons for the taser failing to induce compliance in a subject. Reasons for failure of the taser are discussed below.

i) Clothing

Although the electrical current from the taser can arc across a certain distance of air-gap, there may be some situations where the thickness of the clothing worn by the subject exceeds this distance. This is especially important in cold climates where heavy jackets are frequently worn.

Additionally, if clothes are hanging loosely away from the body and the barbs attach to the clothing without penetrating the body, then the arc distance could again be exceeded. This will cause the circuit to be incomplete and electricity will not flow through the subject.

ii) Battery Failure

Low battery charge can be caused either by the depletion of the battery through continued use or by very cold weather conditions, which can adversely affect their performance. Maintenance of taser equipment is vital to ensure that the taser will be in good working order when required. One American Sheriff's Department highlighted battery failure and poor maintenance as a reason for failure of their previous taser units and another department noted battery failure as one of the primary reason for ineffectiveness. This usually occurred when the batteries had not been fully charged.

Different types of batteries have different performance characteristics. While rechargeable batteries can last for a greater number of uses than alkaline batteries, for instance, they will be ineffective if regular and appropriate recharging of them is not carried out. Cold conditions can also adversely affect different battery types to different extents.

iii) One or Both Barbs Fail to Hit the Target

One or more barbs can fail to strike the target for a number of reasons including operator error, errors in the sighting system, cartridge failure, moving target and the target being out of range. Unless both barbs hit the target the electrical circuit will be incomplete and electricity will fail to flow through the subject.

iv) Subject Fighting Through the Effects of Electricity

Even with the new higher-powered taser devices, some subjects are capable of fighting through the effects of the electricity[5], although this is a much less common cause of failure than many of the others listed here. The ability of a subject to withstand the electrical current effects will depend on their mental

focus, the power output of the taser and the distance between the two barbs (hence stun guns tend to be less effective than tasers). A study by the RCMP using police volunteers found that the taser was more effective when applied to the back and legs than to the chest or arms[5].

v) Operator Error

Examples of operator error may include failure to hold down the trigger to maintain the flow of electricity through the subject (on some models) or failure to operate the taser in the correct manner.

vi) Deploying Too Close to the Target

The length of the connecting wires sets the upper limit of the range over which the taser is effective. The lower limit is set by the spread of the barbs. In order to incapacitate the subject the electricity should cover as many large muscle groups as possible. Use of the taser at ranges lower than three feet (0.9m) may not allow sufficient separation of the barbs to occur.

vii) Taser or Cartridge Failure

Problems can occur with the taser unit itself during use, such as a mechanical problem or an electrical failure in the circuit. This can result in the trigger not being able to be depressed, or the electricity being unable to flow, for instance. Cartridge failures have also occurred operationally, such as the barbs not ejecting from the cartridge when the taser is fired.

2.5 Conclusions

Tasers have a number of characteristics that may make them suitable for use by UK Police forces. However, a major drawback to their effectiveness could be the maximum range of 21ft (6.4m) imposed by the length of the conducting wires, which is combined with an effective range of only 15ft (4.6m) for acceptable accuracy. Additionally, tasers are not 100% effective. This can be as a result of the electricity failing to incapacitate the subject, although other causes may be more likely. Main reasons for failure include one or both barbs missing the target, thick or loose clothing, battery failure, operator error, tasers deployed too close to the target, or the taser or cartridge failing.

Tasers are often effective without the need to fire the barbs. They can be used in stun mode as well as using the laser sights and/or sparking the taser in view of the subject before inserting the cartridge as a deterrent. In these cases the threat that the officer is about to use the taser may be sufficient to induce compliance.

Throughout testing and in the handling trials the variation in the performance and handling characteristics of the different models of taser became apparent. Although details of this are classified as RESTRICTED COMMERCIAL and so cannot be detailed here, they have been passed to ACPO and UK Police forces to assist them in their decision making.

PSDB's evaluations have deliberately only assessed the scientific and technical aspects of tasers. It has not addressed any policy considerations or many operational aspects, such as the legal implications, acceptability (to both the police and the public), authority required to use, who should carry tasers if they are to be deployed and judgement issues. These issues must be addressed by Home Office ministers, ACPO and the NIO, although PSDB has provided technical guidance where appropriate. Likewise, PSDB has not assessed the medical implications of the use of tasers. This expertise has been provided by Dstl and details on this aspect of tasers are provided in their section of this report.

Tasers have been found to produce electro-magnetic fields that can interfere with other electrical equipment. A study[8] has found that there is no interference with the Airwave TETRA communication system but recommends that testing be carried out with other items of police electrical equipment if tasers are likely to be used in close proximity to them.

It has also been found that tasers can set fire to flammable liquids. Therefore, it is strongly recommended that the taser is not used against a subject who has already been sprayed with either CS or PAVA, both of which are currently contained within a flammable solvent (MIBK and 1:1 ethanol:water respectively), if it is possible to avoid doing so. Extreme caution must also be exercised when using it on a subject who is suspected of being covered in any other flammable solvent, such as strong alcohol (e.g. undiluted spirits) or petroleum spirit, or in a dangerous environment, such as a petrol station.

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