Home Office

CED Replacement Project

Assessment of the Taser X2 against the police operational requirements

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Summary

The model of conductive energy device (CED) that is currently in service with the UK police is the Taser X26E CED. This model is commonly known as the X26. The Taser X26 is manufactured in the United States of America by TASER International. In January 2014, TASER International announced that they would be discontinuing sales and production of the Taser X26 after 31 December 2014.

In Spring 2015 the Chair of the National Police Chiefs Council (NPCC) Less-Lethal Weapons Working Group commissioned the Home Office Commercial Directorate – Police Commercial to undertake a procurement process on behalf of UK police forces to identify a suitable replacement CED for the X26 that met the police operational requirements.

The Cabinet Office and the Home Office Commercial Oversight Group approved a procurement strategy and an Official Journal of the European Community (OJEU) Open Procedure and an Invitation to Tender (ITT) was published by the Home Office Commercial Directorate in October 2015. The ITT contained the police operational requirements (Appendix A).

After the Home Office Commercial Directorate had assessed the bidders' submissions to the ITT, one CED, the Taser X2, was identified as meeting the requirements to proceed to a technical assessment.

The Home Office Centre for Applied Science and Technology (CAST) were commissioned to undertake the assessment of the Taser X2 against the operational requirements and assess the likely performance characteristics. The assessment and results are contained within this report and, where appropriate, the performance is compared to the X26. The technical assessment was separated into two stages: CAST testing, which included a number of repeatable tests to assess performance and consistency; and a user handling trial, which involved 18 volunteer police officers completing a series of scenario exercises and answering a questionnaire to capture their views. The volunteer officers comprised of 12 who were Taser trained and current users of the X26, and six officers who had no previous Taser experience or training.

Compared to the X26, the X2 is a new design with additional functionality and has the capability to fire two shots, one after another without reloading, making a second shot more readily available to the officer if required. The X2 also has dual laser sights to indicate the impact point of the top and bottom barbs, and can generate a warning arc without having to unload the cartridges.

One significant difference between the X26 and the X2 is the pulse waveform that is delivered to the subject. As part of a Memorandum of Understanding between Home Office Science and the Department of National Defence Canada, Defence Research and Development Canada (DRDC) took the lead to conduct tests on the electrical output of the X2.

From the tests conducted, the X2 met the police operational requirements and no significant technical problems were identified. The X2s that were tested passed the electrical output tests, meeting the manufacturer's specifications.

This report contains the methodology and results from the tests; the main findings in the three key areas are as follows.

Technical:

- The X2 was found to be durable and sufficiently robust to pass the drop tests, and also performed without problems when used by the officers during the handling trial in a similar manner to that which would be encountered during training and operationally.

- The X2 cartridge has an extended range (25 ft) compared to the standard X26 cartridge (21 ft) that is deployed operationally in the UK.

- The X2 cartridge submitted for this evaluation contains newly developed Smart Probes (SP), which are 11.5 mm long compared to the X26 barb probe which is 9.65 mm long.

- The X2 showed an improved accuracy and consistency compared to the X26 with tighter grouping of shots closer to the point of aim indicated by the laser sights.

- Utilising the X2's dual laser sights, the accuracy of the bottom barbs compared to point of aim indicated by the laser sight was comparable to the accuracy of the top barbs.

- The maximum velocity of the X2 SPs were measured to be 10 m s^{-1} higher than the probes fired from the X26 cartridge and the variation in the velocity range was greater. This has an influence over the impact energy of the barbs which is counteracted to an extent (but not equalled) because the SP probes are lighter in mass.

- During the handling trial, the performance of the X2 batteries showed a considerable improvement in the percentage usage per activation compared to the X26.

- Measurements of the X2 laser sights were tested by Public Health England (PHE) and concluded that the output is similar to the X26 laser sight and not to be intentionally aimed at the eyes. The laser sights are considered to be Class 3R as defined in BS EN 60825-1. PHE suggested that TASER International supply the X2 with labelling that complies with IEC 60825-1 2014, which is identical to the British Standard. Intentional viewing should be avoided. If accidental eye exposure does occur, there are specific post-incident duties on the employer specified in the Control of Artificial Optical Radiation at Work Regulations 2010.

User handling:

- The X2 showed an improved number of both barb hits (94%) over the X26 (91%).

- The results from all three groups demonstrated that it was possible to take two shots with the X2 in less than half the time it took to take a shot, reload and take the second shot with the X26.

- Several users commented to say that the grip of the X2 was too short or that they preferred the grip of the X26.

- Four officers felt the X2 was more difficult to reload or preferred reloading the X26.

- 100% of the Taser-trained officers preferred the X2 over the X26.

- The manufacturers say that unlike the X26 cartridges, the X2 cartridges are designed to be resistant to static discharge. This reduces the risk of inadvertent activation of the cartridge caused by static discharge, which improves cartridge handling safety.

- Overall, the general views were that users preferred the dual laser sights, and having a more readily available second shot capability from the X2 and the confidence it gave in being accurate and providing a backup shot. These features were felt to outweigh the drawbacks of the grip of the X2 being too short and not as good as the X26, and the slight difficulties experienced with reloading the X2. These could be addressed through training and further familiarisation.

System

- Connecting the X2 to a computer in offline mode (using the Evidence Sync™ application) stores the firing log data on the local computer as a report in .pdf format. When connected in online mode, the firing and pulse logs are stored within a cloud-based application called Evidence.com™. The pulse logs are a record of the electrical (output) pulse activity and are only available in online mode.

- In order to centrally administer any changes to the Taser X2 system, where software and firmware is capable of modification or upgrades, the ITT issued by the UK has requested that TASER International submit the details of rationale for the upgrade or modification to the Authority (e.g. CAST) in advance of any implementation in the UK. TASER International agreed that such upgrades and any modifications will only be applied after permission is granted by the Authority.

Table 1: A summary of the positive and negative aspects of the X2 (compared to the X26)

Taser model	Positive aspects	Negative aspects
X2	• Two-shot capability reducing time to take a second shot if required; • Dual laser sights enhanced officer confidence; • Delivering a warning arc without having to unload the cartridge; • Employs charge metering to adjust the electrical output; • X-connect feature to allow a second shot to achieve larger barb separation; • More accurate and consistent shots than the X26 in the lab tests; • Most accurate during the handling trials with the highest percentage of both barb hits; • Overall the X2 was the 100% preferred choice by the Taser-trained participants in the user handling trial; • All users, including new users, found the X2 easy to operate.	• Larger and heavier than the X26; • Possible increase in risk to the subject from skin penetration from the longer and new design SP barbs; • Larger range between the minimum and maximum velocity of the SP barbs; • The cartridges and batteries are more expensive than the X26; • Grip was felt to be too short; • Cartridge eject button is difficult to operate; • Additional training required compared to the X26 to cover additional features.

The testing and evaluation described in this report covers the police requirements and can be used to predict how well the X2 can be expected to perform operationally by comparing its performance to the current operational weapon, the X26. However, certain new features of the X2, most notably the new waveform, cannot be directly compared to the X26 with regard to effectiveness and safety. Relative safety will be covered by referral to Scientific Advisory Committee on the Medical Implications of Less-Lethal Weapons (SACMILL) but effectiveness will necessarily be determined during operational use. This can be measured during a limited period of monitoring of operational use in a small number of forces. This period of monitoring can also be used to ensure the injury potential predicted by SACMILL is as expected, and is recommended by CAST to enable additional validation of data and predictions from this trial. A similar process was followed when the X26 replaced the M26.

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1. Introduction

1.1 Background

The model of conductive energy device (CED) that is currently in service with the UK police is the Taser X26E CED. This model is commonly known as the X26. The Taser X26 is manufactured in the United States of America by TASER International. In January 2014, TASER International announced that they would be discontinuing sales and production of the Taser X26 after 31 December 2014[1] and not service any X26s over five years old. To replace the X26, two new models of CEDs were developed by TASER International and have been released to the market, namely the Taser X26P and the Taser X2.

In Spring 2015, the Chair of the National Police Chiefs Council (NPCC) Less-Lethal Weapons Working Group commissioned the Home Office Commercial Directorate – Police Commercial to undertake a procurement on behalf of UK police forces and law enforcement agencies to establish a new national procurement framework for CEDs. This will be open to all police forces in England and Wales, Northern Ireland, Scotland, and those outside mainland UK.

In October 2015, the Cabinet Office and the Home Office Commercial Oversight Group approved a procurement strategy to hold an open competition to establish a new national procurement framework. This requirement was subject to the Official Journal of the European Union (OJEU) Open Procedure and an ITT was published by the Home Office Commercial Directorate in October 2015. The ITT contained the police operational requirements (Appendix A). The tendering exercise included stages of technical assessment for the CEDs that successfully reached the technical assessment stage.

The only CED that was submitted to the ITT and successfully reached the technical assessment stage was the Taser X2. Home Office CAST was commissioned to undertake an assessment of the Taser X2 against the operational requirements and assess the likely performance characteristics. The assessment and results are contained within this report and, where appropriate, the performance is compared to the X26. The technical assessment comprised of two stages, which are identified in the operational requirements in Appendix A as:

- CAST testing
- User handling trial

The CAST testing comprised of a number of repeatable tests to assess performance and consistency. The user handling trial involved volunteer police officers completing a series of scenario-based exercises and completing a questionnaire to capture their views.

1.2 Aim of the assessment

The primary aim of this work is to conduct an independent assessment of the Taser X2 CED against the operational requirements published in the ITT. The results will be supplied to the Home Office Commercial Directorate as scores or pass/fail for mandatory requirements and will form part of the evaluation of the ITT. Where possible, performance, consistency and reliability comparisons are made between the X2 and the Taser X26 currently deployed operationally by the UK police. Other tests may be employed to obtain additional information.

1.3 Operational requirements

In January 2013, the National Conflict Management Portfolio reviewed and ratified a series of police operational requirements to cover less-lethal technologies. The CED-specific requirements were extracted from this parent document and formed the basis for the operational requirements published in the ITT. The CED-specific operational requirements for the CAST testing and user handling trial are included in Appendix A.

1.4 Previous work

In 2004, CAST conducted similar work when TASER International last released a new model of CED. At that time it was the Taser X26 superseding the M26. This previous work was carried out by the Police Scientific Development Branch (PSDB), which is now CAST, and published in PSDB Further Evaluation of Taser Devices 19/05[2]. The test methodology used in this work forms the basis for this assessment.

After TASER International released the Taser X26P and X2 (explained in 1.1), CAST conducted an assessment in 2014 to compare the Taser X26P and Taser X2[3] to the X26. As part of that work, tests were carried out using both models and in some sections of this report it will refer to the X26P and X2. In particular, the tests measured the laser sight, the electrical output test and the EMC testing.

The ITT released in October 2015 stated that results from testing carried out by CAST since 1 January 2014 can be used as evidence against meeting the operational requirements for the current stage of CAST testing. The manufacturer has confirmed that no changes have been made to the main body of the X2 since the original 2014 testing by CAST. This approach avoids repeating tests unnecessarily and provides value for money for the taxpayer.

However, modifications have been made to the design of barb probe that is fired from the 25 ft operational cartridge fired from the X2; therefore, any related tests such as accuracy and consistency have been repeated.

1.5 Collaboration

In February 2014, a Memorandum of Understanding was signed between the Home Office and the Department of National Defence Canada to enable formal information sharing on less-lethal weapons or non-lethal weapons on matters concerning public security and safety, and cooperative science and technology. This resulted in CAST partnering with Defence Research and Development Canada (DRDC) for the 2014 CAST testing. DRDC took the lead in the work to produce a test plan and conduct electrical output measurements on the X26P and X2, producing a report of their findings[4].

1.6 The future

As part of CAST's technology watch, other types of CED which emerge onto the market are of interest to CAST and need to be considered for their suitability. This activity is completely outside this procurement process. This horizon-scanning activity is conducted using data from manufacturers and information from law enforcement and agencies similar to CAST in North America and Europe.

1.7 Comparing the X26 with the X2

This section provides a brief overview of some of the additional features of the X2 compared to the X26. A more detailed comparison is available in the next chapter and found in the TASER International User Manual[5].

- Two-shot capability making a second shot more readily available;
- A more robust construction with better weatherproofing;
- An extended battery life;
- Self-diagnostic checks;
- Charge metering to optimise the delivery charge;
- Dual laser sights;
- A warning arc (spark) which can be generated without having to unload the cartridge;
- More detailed central information display (CID);
- More detailed firing logs;
- Access to an image of the pulse log in Portable Document Format (.pdf) (online only);
- Online firmware upgrades (online only);
- A new design Smart Probe (SP) in the operational cartridges, designed to improve barb retention.

1.8 Data download and firmware updates

Currently, firmware updates for the X26 are released by TASER International in the form of a new battery known as a Digital Power Magazine (DPM), which has the latest version of firmware programmed into it. When the DPM is inserted into the X26, the new firmware is automatically uploaded. An event log containing the X26 firing data can be downloaded by connecting the X26 to a computer that has the X26 Dataport Download software installed. The firing data can be saved on a local computer.

Similarly, the data can be downloaded by connecting the X2 to a computer and using a software application called Evidence Sync™. This application can be used in an online or offline mode. Varying levels of detail are available from the X2 data download depending on the mode of Evidence Sync™ used. A summary of some key options available in each mode are shown in Table 2 and further details given in the X2 User Manual[5].

Three types of logs can be accessed through Evidence Sync™. TASER International calls these logs 'Trilogy Logs' which represent event, pulse and engineering logs. The X2 event log captures the firing events similar to the X26 but includes more detailed information – the pulse log displays an image of the electrical pulse activity and the engineering log records the performance of the unit. The pulse logs are only displayed as a chart in .pdf format. It is not possible to see the raw data that are used to create the charts which would be more useful. To access the Trilogy Logs

the X2 needs to be connected to Evidence Sync™ online. In offline mode, the X2 pulse logs cannot be seen but the event logs can be viewed and saved in .pdf format on a local computer.

The X26 event log can also be downloaded using Evidence Sync™ but no additional information is available over a download using the Dataport Download software. A summary of the differences in the detail in the event log between the X26 and X2 are explained later in Section 2.8. X26 firmware updates cannot be administered using Evidence Sync™.

For this assessment, Evidence Sync™ (version 3.14.37) was used in offline mode to download the event logs from the X26 and X2. The online version does not form part of this assessment.

The level of accessibility within the Evidence Sync™ application can be configured using administrative functions.

Table 2: Evidence.Sync™ key options

	Evidence Sync™		
	Offline	**Evidence.com Lite™ (Online)**	**Evidence.com Pro™ (Online)**
Event logs that include firing and safety activation log and Taser specific details (serial number, health status etc.)	Yes	Yes	Yes
Pulse logs	No	Yes (as PDF only)	Yes (as PDF only)
Firmware upgrade	Download from www.TASER.com	Online	Online
File storage	Offline (local)	Online (cloud)	Online (cloud)
Upload and storage of videos, files in other formats, mapping, information sharing and build incident cases	No	No	Yes
Cost	Free	Free	Dependant on price plan and data storage requirements

Connecting to Evidence Sync™ online, with the appropriate administrative settings, the firmware version installed in the X26P or X2 will be detected. If a newer version of firmware is available, the user will be asked if they wish to install it. The Trilogy Logs are automatically uploaded through Evidence Sync™ to a cloud-based information management application called Evidence.com™.

In offline mode and when firmware updates are available, they can be downloaded from the TASER International website and installed by connecting the Taser to the same computer and selecting the option to update firmware.

In order to centrally administer any changes to the Taser X2 system, where software and firmware is capable of modification or upgrades, the UK has requested that TASER International submit the details of rationale for the upgrade or modification to the Authority (e.g. CAST) in advance of any

implementation in the UK. TASER International agreed that such upgrades and any modifications will only be applied after permission is granted by the Authority.

1.9 This report

This report includes the test methodology and results from the assessment of the X2 against the operational requirements (Appendix A) and, where appropriate, compares the performance and handling characteristics with the X26.

The report will be submitted to SACMILL and will form part of a package of materials used as reference material for their consideration towards and medical implications that may arise from the X2.

This report may refer to CEDs or Taser devices at times, in particular when referring to earlier work as described in Section 1.4. CED is the generic term and Taser the trademark of the devices that have been used in the UK to date; however, for the purposes of this report they are considered to be the same.

This report assumes the reader has some previous knowledge of Tasers, in particular the Taser X26 and associated terminology, and is divided into eight chapters including this introduction.

- Chapter 1 provides a background to the origin of the work, explains previous work and provides a brief overview of the X2.
- Chapter 2 introduces the Taser X2 CED, provides a brief overview of its features and functionality, and provides comparisons with the X26.
- Chapter 3 describes the CAST tests including the EMC tests and summarises the results.
- Chapter 4 explains the user handling trial introducing the participants and the exercises. The results are summarised and include the user feedback from the questionnaires.
- Chapter 5 records any problems or faults that were experienced with the Taser models or cartridges during the assessment.
- Chapter 6 presents the electrical output tests conducted by DRDC and includes a summary of the findings. The details of the full test report are contained within the references.
- Chapter 7 draws conclusions on how the X2 addresses the operational requirements, compares the X2 with the X26, and includes a summary of the comments made by the officers who participated in the user handling trial.
- Chapter 8 lists some further work that may need to be conducted and includes recommendations based on the findings from this report.

In addition to these chapters are the following appendices:

- Appendix A lists the police operational requirements that relate to Tasers and how those requirements are tested in this assessment.
- Appendix B includes details of the CAST drop tests.
- Appendix C includes the method and the results from the accuracy and consistency test.
- Appendix D includes the results from the user handling trial scenario-based exercises.
- Appendix E includes the participant questionnaire that was completed by all of the participants at the end of the user handling trial and a summary of responses.
- Appendix F includes the results from the testing of the laser sights by PHE.

Amendments

This report was originally submitted to Dstl as SACMILL's technical advisors in June 2016. Subsequently the following clarifications have been made in July 2016:

- Table 9 bottom barb measurements are from the bottom laser dot point of aim to the mean point of impact of the bottom barbs.
- Table 10 mean radius for the X2 operational cartridge at 1.5m (15 ft) is 0.5 cm.
- In question 14 of the questionnaire responses from one of the new users for the Taser X2 is red.

The report dated July 2016 (v2) was subject to further review and the following amendments and typographical corrections have been included in this revision of the report dated November 2016 (v3).

- Section 1.8.Evidence Sync™ version 2.9.2 corrected to version 3.14.37.
- Section 4.6.2 Table 24, X2 both miss shots corrected from 508 to 505 and X2 both miss on two occasions (Ex 5 and Ex 8).
- Section 4.7.1. Question 12 response amended from 66% to 67%.
- Section 3.2 Results of additional drop tests with the Taser X2 in the "armed" are added.

Appendix D

- Exercise 1. New user number of shots for X2 corrected from 35 to 36.
- Exercise 8. 34 shots corrected to 31 and graphical scale corrected.
- Exercise 11. Total number of shots for AFO+ STU for X2 is 36.
- Exercise 12. AFO+STU for X2 title corrected to Exercise 12.

2. Comparison between X26 and X2 CEDs

2.1 Introduction

This chapter introduces the background to the assessment, the Taser X2 and how it compares to the X26. It explains the models, their components and provides an overview of the features and functionality of each model.

CAST (when previously known as PSDB) produced a report[2] in 2005 comparing the Taser X26 with its predecessor, the Taser M26, which led to the Taser X26 being deployed by all UK police forces. A similar approach has been adopted in this work to compare the X26 (Figure 1) with the X2 (Figure 2).

Figure 1: Taser X26

Figure 2: Taser X2

The main components of the Taser X2 are the same as the X26 – the body (or handle), the cartridge and the battery. Figure 1 shows an unloaded X26 and Figure 2 shows the X2 handle without the cartridges loaded and with the battery removed.

The X26 can fire one cartridge before requiring reloading and has a range of 6.1 m (21 ft). The X2 is loaded with two cartridges and has the capability to fire two shots, one after another. The X2 cartridges have a range of 7.6 m (25 ft) and are different to the X26 cartridges. Details about the cartridges used in this assessment are in Section 2.5.

The X26 battery is called a Digital Power Magazine (DPM). The battery for the X2 is called a Performance Power Magazine (PPM). TASER International has produced a number of versions of PPM for the X2. The version of PPM used in this assessment has a built-in capability that automatically stops the Taser X2 cycle five seconds after activation, regardless of whether the trigger is still being pulled by the user. This battery is called the Auto-shutdown Performance Power Magazine (APPM). The APPM was used in this assessment because it goes some way towards addressing the DOMILL recommendation included in their 6th Statement[6] where DOMILL (now SACMILL) considers that the duration of the Taser discharge should be limited. Details about the APPM are in Section 2.4.

TASER International list the enhanced features of the X2 as having extended battery performance (explained later), better weatherproofing to resist rain and humidity conforming to the IEC Standard 60526 to IPx2 rating, self-diagnostic checks on the health and status of the unit, and faults diagnostic displays via the CID. The X2 also has additional features such as two-shot capability, dual laser sights and the capability to produce a warning arc without having to unload the cartridges.

The most significant difference between the X26 and the newer X2 is the electrical output characteristics which are described in the DRDC report[4] and reproduced in Figure 3. The waveform and electrical outputs that are delivered to the subject are different to the X26 and this information will be provided to SACMILL to consider the medical implications of these differences. The X2 also employs 'charge metering', which is described as the Taser's ability to measure the electrical output, pulse by pulse, to optimise the delivery charge depending on the load characteristics. Charge metering occurs whether the barbs have been deployed or direct contact (drive stun) is made. Charge metering works by the Taser sensing a change in circuit impedance; it then adjusts its output to achieve the desired output charge via a feedback system.

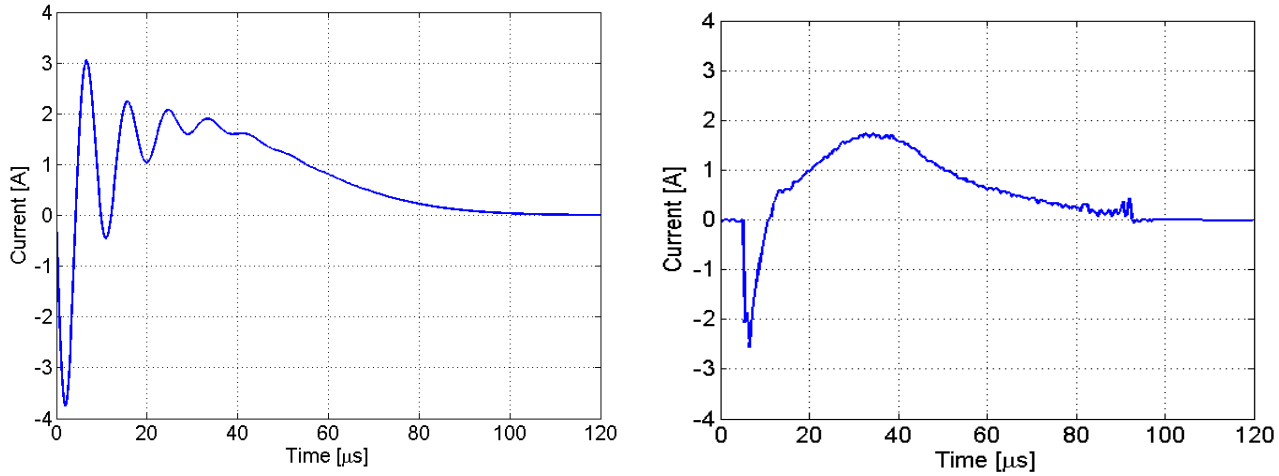


Figure 3: Typical pulse of a Taser X26 (left) and X2 (right)[7]

2.2 Taser X2 characteristics

The X2 is larger and heavier than the X26. Without a cartridge loaded the X26 is considerably shorter in length than the X2. However, once the X26 is loaded with a cartridge on the front it is approximately the same length as the X2. This is because the two X2 cartridges are loaded and housed within the body of the handle so as to be flush with the front of the X2, as shown in Figure 4. There is no facility to store a (third) spare cartridge on the X2.The key features of the X2 are labelled and shown in Figure 4 and Figure 5.

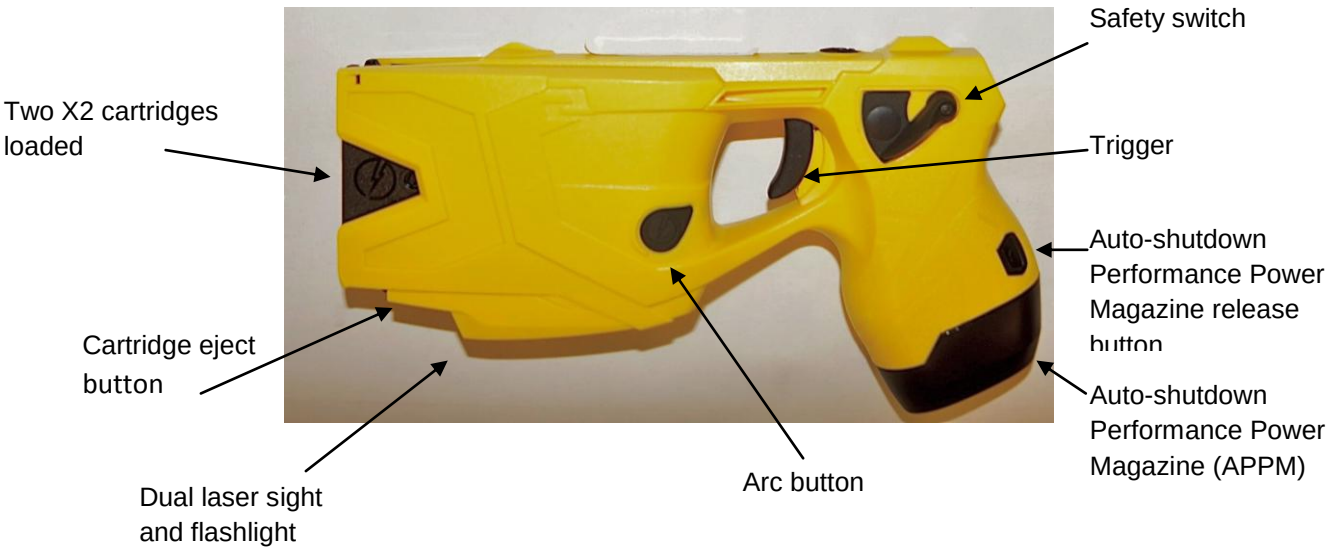


Figure 4: Taser X2 shown with cartridges loaded and APPM battery fitted

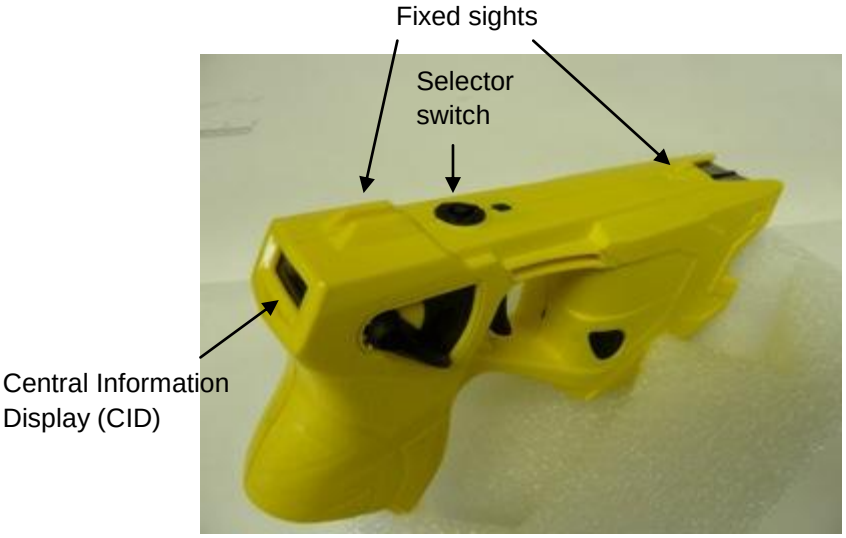


Figure 5: Taser X2

The dimensions and mass of the X26 and X2 can be compared in Table 3. For indication purposes only, this table also includes the price of the handle quoted in the UK supplier's 2016 price list (excluding any extended warranty plans).

Two cartridges are loaded into the X2, one in each bay. The bays are denoted as bay 1 (left-hand side from firer's position) and bay 2 (right-hand side from firer's position). The cartridges are released by pressing the cartridge eject button. With the safety off, the CID will display the type of cartridges that are loaded (Figure 6 on page 20). The dual laser sights on the X2 indicate the aim point of the top and bottom barb. The bottom laser sight flashes to identify the aim point of the bottom barb.

The arc button performs three functions: a short press is a cartridge selector to toggle between the cartridges; a sustained press will generate a warning arc; and if one or both cartridges have been fired and the probes have been deployed, a sustained press on the arc button will re-energise both bays and will remain energised until the button is released. This is the arc button default setting. Administrative access is required to change the configuration of the arc button.

The configuration of the laser sight and LED flashlight are changed using the selector switch.

Table 3: Dimensions of the Taser X26 and X2

Taser model and cost	Physical dimensions and mass	
X26  Cost of X26 handle only (2016) £850*	Length with XDPM fitted	15.5 cm without cartridge; 18.5 cm with cartridge loaded
	Width (widest)	3.8 cm
	Height with XDPM fitted	10.3 cm
	Mass (body only)	186 g
	Total mass with XDPM fitted and one cartridge loaded	295 g
X2  Cost of X2 handle only (2016) £750*	Length with APPM fitted	19.8 cm without cartridges; same length with cartridges loaded
	Width (widest)	4.4 cm
	Height with APPM fitted	11.0 cm
	Mass (body only)	284 g
	Total mass with APPM fitted and two cartridges loaded	437 g

*Costs published in the Axon Public Safety UK Limited 2016 price list

Visually and dimensionally, the X26 and X2 vary and are clearly different with the X2 appearing to have a more robust appearance and construction to the X26. The ambidextrous safety levers protrude from the sides of the Tasers and the measurement for the width corresponds to the width at that point.

The circumference of the grip for the X26 is approximately 13.5 cm compared to the X2 which is approximately 14.5 cm. When the X2 is loaded with two operational cartridges it weighs 437 g which is 142 g heavier than the loaded X26 (295 g). However, an officer would typically carry the X26 with a spare cartridge stored in the XDPM, the mass of the X26 increases to 352 g.

2.3 X2 Advanced Central Information Display (CID)

Compared to the X26, the CID on the X2 is smaller and displays more information in the form of clearly legible symbols, as shown in Figure 6. Because of the extra features, the X2 CID shows additional information. The CID also displays faults that may have been detected during the self-diagnostic checks or that may occur during operation. These are explained further in the X2 User Manual[5].

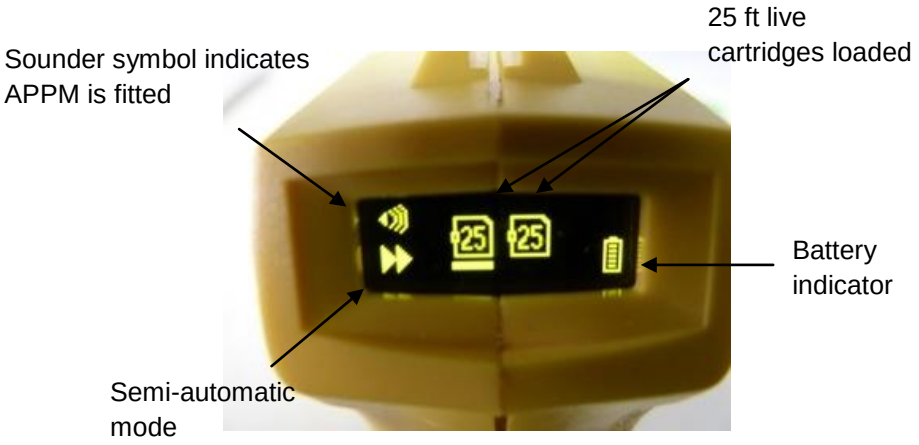


Figure 6: The X2 Advanced CID

The battery indicator on the CID is similar to a mobile phone showing the battery level as a series of bars; each bar represents approximately 20%. A numeric battery percentage reading can be obtained from a data download or by pressing the selector switch on the X2 and toggling through the menu.

The battery pack used in the X2 contains a memory device that stores the total battery capacity and total power consumed. These two values are used to calculate the remaining battery percentage by subtracting the power consumed from the battery capacity available. The X2 has a sensing circuitry that measures the current drawn by the Taser during a deployment. The Taser then adds the current used to the total power consumed in the battery pack.

2.4 Auto-shutdown Power Performance Magazine (APPM)

TASER International produces a variety of different battery options for its devices. The options used in this assessment were the eXtended Digital Power Magazine (XDPM) in the X26 and the APPM fitted to the X2. The user is made aware that the X2 is fitted with the APPM by the sounder symbol that is displayed on the CID (see Figure 6). When the trigger is pulled to activate a five-second cycle, the audio sounder starts to beep when the CID displays four seconds. The beep continues to sound for the fourth and fifth second of the activation and then stops automatically whether the trigger is still being activated or not.

If the trigger is being held down, the cycle will automatically stop after five seconds but the audio sounder will continue until the trigger is released. To re-energise the X2 cartridge that has been fired the officer must press the arc button. Note that if the X2 trigger is pulled again, the second cartridge will be deployed.

When the arc button is pressed, the auto-shutdown feature does not activate and the cycle will continue as long as the button is being depressed (arc switch over-ride). With the appropriate administrative access rights, this function can be altered so the cycle will stop after five seconds regardless of whether the trigger or arc button are being activated (hard stop).

Selecting the APPM options for this assessment (Table 4) goes some way to address the recommendation in the 6th DOMILL Statement[6] where *DOMILL "Considers that the duration of the application of Taser discharge should be limited to that necessary to achieve the desired operational effect"*.

Table 4: Battery options for the X26 and X2

Battery type fitted to the X26 and X2 during the CAST assessment		
Battery	**XDPM** **eXtended Digital Power Magazine**	**APPM** **Auto-shutdown Power Performance Magazine**
Primary Taser	**X26**	**X2**
Image		
Voltage	2 x 3 volt lithium cells	3 x 3 volt lithium cells
Cycle	Provides approximately 195 five-second cycles	Provides approximately 500 five-second cycles
Function	Extends the grip and holds a spare X26 cartridge for quick reloading	An audible beep sounds when the CID displays four seconds andthe cycle automatically stops after five seconds
Mass	52 g	71 g
Cost (2016)	£50*	£50*

*Costs published in the Axon Public Safety UK Limited 2016 price list

All of the battery options are single use only and not rechargeable, and non-shutdown PPM options are available. The only power source that is rechargeable is the audio-video recording option using the TASER CAM.

2.5 Cartridges

The range of cartridges used in this assessment and the details are shown in Table 5.

Table 5: The features of the cartridges for the X26 and X2

Cartridge type	X26 21 ft operational	X26 training	X2 25 ft operational	X2 training	X2 simulation
Image					
Range	21 ft / 6.4 m	21 ft / 6.4 m	25 ft / 7.6 m	25 ft / 7.6 m	N/A
Probes					N/A
Purpose	Standard 21 ft operational cartridge	Training cartridge with short barbs and non-conductive wire used in conjunction with protective suit	Standard 25 ft operational cartridge with SP barbs	Training cartridge with short barbs and non-conductive wire used in conjunction with protective suit	Simulation cartridge for training and has no deployable probes
Propellant	Compressed nitrogen gas				
Colour	Black body with silver blast doors with clear transit cover	Blue body with blue blast doors with clear transit cover	Black body with black blast doors and green transit cover	Black body, blue blast doors and blue transit cover	Black body, with transparent blast doors. No transit cover
Barb probe dimensions	Brass and aluminium 27.7 mm long, 5.4 mm diameter, probe mass 2.8 g		Cast alloy 22.6 mm long, 5.3 mm diameter, probe mass 2.6 g	Brass and aluminium 27.7 mm long, 5.4 mm diameter, probe mass 2.8 g	N/A
Barb (approx.)	Barb length 9.65 mm, 0.9 mm diameter	Barb length 6.35 mm; 0.9 mm diameter	Barb length 11.5 mm, 0.76 mm thick,1.7 mm (widest point).	Barb length 6.35 mm; 0.9 mm diameter	N/A
Cartridge weight	57 g	51 g	40 g	37 g	24 g

Cartridge type	X26 21 ft operational	X26 training	X2 25 ft operational	X2 training	X2 simulation
Angle of separation	Barbs leave cartridge at an angle of 8^{o}		Barbs leave cartridge at an angle of 7^{o}		N/A
Velocity (first 30 cm from muzzle)	42.0 m s^{-1} max. 39.1 m s^{-1} min. 41.1 m s^{-1} avg.		52.1 m s^{-1} max. 47.8 m s^{-1} min. 50.2 m s^{-1} avg.		N/A
Cartridge orientation	Cartridge can be inserted in any orientation		Cartridge can only be inserted in one orientation		
Cost* (2016)	£25* (excl VAT)		£25* (excl VAT)		£25* (excl VAT)
Audit trail	Operational cartridges disperse 30 to 40 small paper discs when fired that are printed with the cartridge unique serial number (AFID tags). Training cartridges disperse blank, blue AFIDS.				
Shelf-life	5 years				

*Costs published in the Axon Public Safety UK Limited 2016 price list

Figure 7 shows the barb probes fired from the operational cartridges of the X26 (top) and X2 (bottom). The standard blunt front bi-metal probe fired from the 21 ft X26 operational cartridge has a fish hook design barb, 9.65 mm long. The X2 cartridge fires a newly developed SP; the SP barb has a two opposing barbs and is 11.5 mm long, 0.76 mm thick and 1.7 mm wide at its widest point(s). The SP barb was designed to increase retention in the subject and clothing.

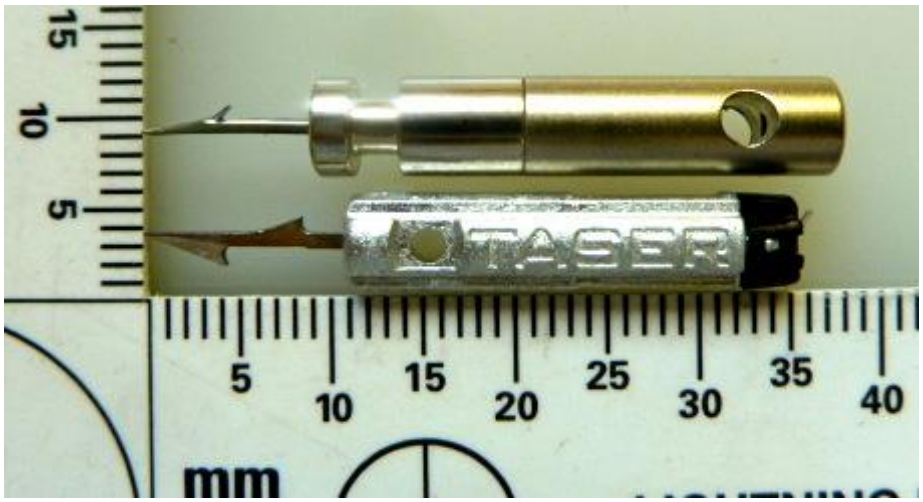


Figure 7: The standard X26 21ft operational probe (top) and the X2 25 ft SP barb probe (bottom)

The SP probe body is manufactured using an injection metal assembly process and is moulded around a new design of spear (barb) to create one component. Table 5 includes further details on the cartridges and probes.

The X2 training cartridge fires the short bi-metal blunt front barb (6.35 mm long) that is identical to the probe fired from the X26 training cartridge.

The X2 operational and training cartridges used in this assessment are marked as Revision D. The 21 ft X26 operational and training cartridges used in this assessment were Revision D and Revision E respectively.

2.6 Cartridge safety issues

Safety warnings issued by TASER International advise that static electricity can cause the X26 cartridge to discharge unexpectedly, possibly resulting in serious injury. The X2 cartridge has been designed to be resistant to static discharge.

2.7 Taser X2 modes of operation

The X2 can be configured (with the appropriate administration rights) to operate in two modes: semi-automatic or manual. All X2s used in this assessment were configured to semi-automatic mode.

In semi-automatic mode, once the cartridge in bay 1 has been deployed and the trigger has been released, the X2 automatically selects the next live cartridge in bay 2. A second trigger pull will deploy the second live cartridge in bay 2. After bay 1 has been fired, it can be re-energised by pressing and holding the arc button. When bay 1 and bay 2 have been deployed, by pressing the arc button, both bays will be re-energised.

In manual mode, once a cartridge has been deployed, the X2 does not automatically advance to the next cartridge. To advance to the next cartridge, a momentary press of the arc button is required. If the X2 is not manually advanced to the next cartridge, a second trigger pull will re-energise the previously deployed cartridge.

An officer can also employ a tactic when using the X2 called a X-Connect™ (cross-connect). Operationally, this is beneficial in incidents where one barb misses the subject or is only partially connected and the deployment is not effective. During a firing at a single subject, as long as at least one of the top probes and one of the bottom probes has achieved a successful contact, a circuit can be completed. This applies even if the barbs were deployed from different bays of the X2, as long as they were fired from the same X2. This tactic of firing a second cartridge can also be employed to achieve large barb separation when using the Taser X2 at close range.

Figure 8 shows the front of the X2 and labels the probes 1 to 4. When both bays have been fired (assuming a good barb connection) a circuit may be achieved by probes 1 and 2, 1 and 4, 3 and 4, or 3 and 2.

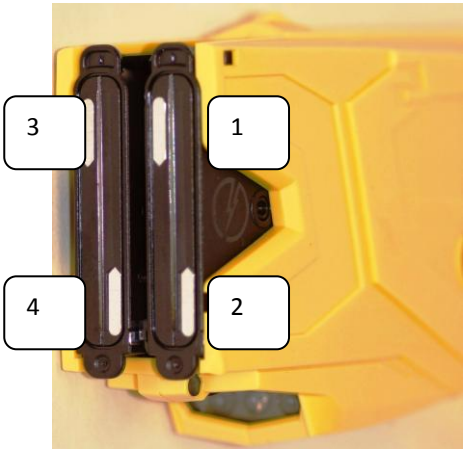


Figure 8: X2 barb probe positions for cross-connect

2.8 Data download

Section 1.8 explained the data download options for the X26 and X2 using Evidence Sync™ and the difference in offline and online functionality.

For this assessment, the event logs were downloaded from the X26 and X2 using Evidence Sync™ in offline mode. Figure 9 shows examples of the .pdf report of the event logs from each device which include:

TASER PROTECT LIFE EVIDENCE SYNC

TASER Information		Offline Report	
Serial	X00-174428	Local Timezone	GMT Daylight Time (UTC +01:00)
Model	TASER X26	Generated On	06 Apr 2016 18:42:16
Firmware Version	Rev. 24		
Application Version	3.14.37		

Device (X26)

Seq #	Local Time [DD/MM/YYYY hh:mm:ss]	Event [Event Type]	Duration [Seconds]	Temp [Degrees Celcius]	Batt Remaining [%]
1	03 Mar 2016 09:31:15	Trigger	5	26	92
2	03 Mar 2016 09:38:23	Trigger	1	22	91
3	03 Mar 2016 09:39:01	Trigger	1	23	91
4	03 Mar 2016 09:39:20	Trigger	1	23	91
5	03 Mar 2016 09:39:36	Trigger	1	22	91
6	03 Mar 2016 09:39:50	Trigger	1	22	91
7	03 Mar 2016 09:40:36	Trigger	5	24	91
8	03 Mar 2016 09:41:57	Trigger	1	24	90
9	03 Mar 2016 09:42:06	Trigger	5	25	90
10	03 Mar 2016 09:44:47	Trigger	1	25	90
11	03 Mar 2016 09:44:58	Trigger	5	26	90
12	03 Mar 2016 10:01:24	Trigger	1	20	89
13	03 Mar 2016 10:01:34	Trigger	5	-1	89
14	03 Mar 2016 10:03:21	Trigger	1	-1	89
15	03 Mar 2016 10:03:30	Trigger	5	22	89
16	03 Mar 2016 10:05:03	Trigger	1	-1	88
17	03 Mar 2016 10:05:11	Trigger	5	23	88
18	03 Mar 2016 10:06:31	Trigger	1	22	87
19	03 Mar 2016 10:06:42	Trigger	5	23	87
20	03 Mar 2016 10:08:38	Trigger	1	23	87
21	03 Mar 2016 10:08:48	Trigger	5	24	87
22	03 Mar 2016 10:11:57	Trigger	1	24	86
23	03 Mar 2016 10:14:39	Trigger	5	24	86
24	03 Mar 2016 10:15:44	Trigger	5	25	86
25	03 Mar 2016 10:18:30	Trigger	5	26	85
26	03 Mar 2016 10:19:21	Trigger	5	26	85
27	03 Mar 2016 10:21:43	Trigger	1	25	85
28	03 Mar 2016 10:21:52	Trigger	5	26	84
29	03 Mar 2016 10:23:02	Trigger	1	26	84
30	03 Mar 2016 10:23:13	Trigger	5	27	84
31	03 Mar 2016 10:24:13	Trigger	1	26	84

TASER PROTECT LIFE EVIDENCE SYNC

TASER Information		Offline Report	
Serial	X00003948	Local Timezone	GMT Daylight Time (UTC +01:00)
Model	TASER X2	Generated On	06 Apr 2016 18:59:16
Firmware Version	Rev. 04.020		
Application Version	3.14.37		
Health	Good		

Device (X2)

Seq #	Local Time [DD/MM/YYYY hh:mm:ss]	Event [Event Type]	Cartridge Info [Bay: length in feet/status]	Duration [Seconds]	Temp [Degrees Celcius]	Batt Remaining [%]
1	10 Mar 2016 21:37:22	Power Magazine Change	Manufacturing S/N: XXXXX6 Battery capacity: 100%			
2	10 Mar 2016 21:37:22	Firmware Update	FW Bundle, Rev. 04.020, 04/08/15			
3	10 Mar 2016 21:37:22	Firmware Update	MC, Rev. 04.019, 03/08/15			
4	10 Mar 2016 21:37:22	Firmware Update	LDR, Rev. 04.013, 16/12/14			
5	10 Mar 2016 21:37:22	Firmware Update	HVM, Rev. 01.005, 04/08/15			
6	10 Mar 2016 21:37:22	Armed	C1: Empty C2: Empty		34	100
7	10 Mar 2016 21:37:33	Safe	C1: Empty C2: Empty	11	34	99
8	10 Mar 2016 21:37:50	Power Magazine Change	Standard S/N: 383368 Battery capacity: 77%			
9	10 Mar 2016 21:37:50	Armed	C1: 35' Training C2: Empty		33	77
10	10 Mar 2016 21:37:51	Safe	C1: 35' Training C2: Empty	1	33	77
11	10 Mar 2016 21:54:52	Power Magazine Change	Manufacturing S/N: DPN800 Battery capacity: 100%			
12	10 Mar 2016 21:54:52	Armed	C1: 35' Training C2: 35' Training		32	100
13	10 Mar 2016 21:54:54	Trigger	C1: Deployed	5		100
14	10 Mar 2016 21:55:00	Trigger	C2: Deployed	5		99
15	10 Mar 2016 21:55:05	Trigger	C2: Deployed	5		99
16	10 Mar 2016 21:55:10	Trigger	C2: Deployed	5		99
17	10 Mar 2016 21:55:16	Trigger	C2: Deployed	5		99
18	10 Mar 2016 21:55:21	Trigger	C2: Deployed	5		99
19	10 Mar 2016 21:55:28	Trigger	C2: Deployed	5		99
20	10 Mar 2016 21:55:33	Trigger	C2: Deployed	5		99

Figure 9: Example data downloads from Evidence Sync™ from X26 (left) & X2 (right)

The event log data recorded by the X2 is significantly more detailed than the X26 and is summarised in Table 6. The X2 also includes the recording of:

- the type of cartridge that is loaded and deployed in each bay;
- whether the trigger or arc button has been activated;
- when the time has been synchronised;
- cartridge faults;
- the battery serial number.

Table 6: Summary of data available from Evidence Sync™ (offline) event log downloads

Data download information recorded	X26	X2
Firing date and time	●	●
Event type	●	●
Cartridge information		●
Duration of activation	●	●
Temperature	●	●
Battery remaining %	●	●
Safety on/off recording		●
Health status indicator		●
Installation of firmware updates		●

2.9 Assessment of the output of the laser sights

In 2014, CAST commissioned PHE to examine the output of the red dot laser sights to compare 12 CEDs. These were four X26s, four X26Ps and four X2s, and the report[13] of the findings is included in Appendix F. The work looked to compare and comment on the laser sights of the X26 and those of the X26P and the X2 (dual lasers) when operated under normal conditions. The examination was to include the measurement of output of the red dot laser sights, comment on the compliance of the labelling against the current standard on laser safety (BS EN 60825:2014) and provide advice regarding any health and safety implications. Figure 10 shows examples of the laser warning labels for each model.

Figure 10: Examples of the label affixed to the X26, X26P and X2 (left to right)

The PHE report makes the following conclusions:

- The Tasers should be considered Class 3R laser products, as defined in BS EN 60825-1:2014. This laser class is similar to Class IIIa with a Danger warning as marked on the devices. To avoid confusion, it is suggested that the manufacturer should be asked to supply the equipment with labelling that complies with IEC 60825-1 2014, which is identical to the British Standard.

- The laser beams exceed the exposure limits for the eye given in the Artificial Optical Radiation Directive, as implemented in the UK as the Control of Artificial Optical Radiation at Work Regulations 2010. Therefore, it is important that the manufacturer's guidance on training is heeded and that the laser beams are not directed into the eyes of those who may be at work. This is likely to be particularly important during training sessions. The exposure limits are set at levels below which eye damage will not occur. Although any accidental exposure of the eye to the laser beams from one of the Taser devices could exceed the exposure limit, it is still considered that the risk of injury is extremely small. However, if a person is exposed to the beam at low ambient light levels, the beam illuminance is sufficient to cause temporary visual impairment.

- If accidental eye exposure does occur, there are specific post-incident duties on the employer specified in the Control of Artificial Optical Radiation at Work Regulations 2010. It is suggested that generic guidance could be developed for police forces on what to do in the event of actual or likely exposure of someone's eyes.

3. CAST testing of the Taser X2 and comparison to the X26

3.1 Introduction

This chapter describes CAST's testing of the TASER International X2 against the operational requirements. Where appropriate, the findings will be compared to the performance of the X26. The manufacturer has stated that there have not been any significant changes to the X2 and the data from previous CAST testing is extant and will be used, e.g. drop test. Where CAST deemed that any changes (e.g. the SP barb) may have an impact on previous data (e.g. accuracy and consistency), the tests were repeated.

3.2 Drop tests

3.2.1 Description

These tests were carried out in 2014 to determine if the X2 is likely to discharge when dropped and what kind of treatment it can withstand while still remaining in a working condition. They were also carried out to determine whether the X2 could be adversely affected while appearing fully functional.

The test was designed to be deliberately extreme to give an indication of any problems that may occur with the device if it is subjected to such harsh treatment.

The drop test involves dropping the loaded X2 from a height of 2 m onto a steel plate in ten different orientations, and observing and recording any damage that occurs. This method is chosen as it is the technique used in the drop tests in the CAST Standard for Police Chemical Irritant Sprays 23/14[7] and is also the same methodology used in the earlier assessment of the Taser devices[2],[3]. The method used and the results can be found in Appendix B.

The X2 was dropped loaded with two operational 25 ft cartridges and fitted with the APPM. After each drop, the X2 was test fired and the APPM function checked. A data download was carried out on both models before and after the drop tests to ensure the firing data had been captured correctly.

This drop test was repeated in 2016 using the same methodology but with the safety switch in the "armed" position. This additional test was carried out to determine whether the cartridges would fire inadvertently. Before dropping the X2 it was secured in a fixture and the reference point of the top and bottom lasers were marked on a target board 3 m from the X2. After each drop the X2 was re-mounted in the fixture and the alignment of the dual laser sights was checked.

3.2.2 Summary

The X2 was dropped ten times from a purpose built drop test rig onto a steel plate as described above and detailed in the methodology (see Appendix B).

The body of the X2 successfully survived the testing with no visual damage other than some minor superficial scratches. After dropping, the safety switch remained engaged (on position) and the CID display functioned correctly on both models, and at no point did the X2 display any faults, function or discharge upon impact.

After drop testing the X2, only one cartridge showed signs of damage (crack) but still fired successfully on the first attempt, as did all of the other cartridges (from both bays).

The auto-shutdown and audio beep still functioned correctly after all of the drops.

When the X2 was dropped ten times with the safety switch in the armed position there were no inadvertently discharges. The alignment of the laser sights were checked after each drop and after ten drops. In all cases the lasers were found to remain aligned to the pre-drop reference position.

3.3 Cartridge drop tests

3.3.1 Description

These tests were carried out on the X2 operational cartridges in 2014. The blast doors of the X26 cartridges are susceptible to damage if they are dropped or suffer a hard impact and not protected by the transit covers. The objective of this test was to determine how robust the X2 operational cartridges are to being dropped, and ascertain the level of damage that may be expected after dropping the cartridges from a height of 2 metres onto a steel plate. With transit covers removed, five 25 ft operational cartridges were dropped in three different orientations: blast doors upwards, blast doors downwards, and with the largest flat side facing down.

After being dropped, any damage to the cartridges was recorded. An attempt was made to fire dropped cartridges where it was deemed safe to do so after a visual inspection.

3.3.2 Summary

Overall, three 25-foot operational X2 cartridges sustained significant damage – one from each drop orientation. Cracks were observed in the blast doors of two cartridges – one dropped from the position with blast upwards and one from the sideways position. Both cartridges fired successfully on the first attempt. When the cartridge was dropped with blast doors downwards the blast doors become detached from the front of the cartridges and the wire loom, barbs and other internal cartridge components spilled out. This rendered the cartridge useless and not safe to fire.

As with the X26 cartridges, the X2 cartridges are still susceptible to damage from dropping. Both types of cartridge are fitted with transit covers which are removed prior to loading into the Taser. When fitted, these protect the cartridge and should reduce the damage to the cartridge if it is dropped inadvertently.

3.4 Accuracy and consistency

3.4.1 Description

The accuracy tests are designed to determine the accuracy and consistency of the X2 when fired from a fixed mount at different ranges. The results were then compared with those for the X26 obtained from equivalent testing by CAST in 2015, using the X26 cartridges and velocity measurements captured in 2014 with the same high-speed camera and set up. The test and results are not intended to replicate the accuracy from hand firing but do give an objective comparison.

When a Taser cartridge is fired, the barbs separate when they are deployed from the cartridge. This barb separation increases as the distance between the subject and the Taser increases. A minimum barb separation of approximately 30 cm (12") is suggested[8],[9] to achieve effective neuro-muscular incapacitation (NMI) from the X26 and X2. The X26 employs a single laser dot sight to indicate where the top barb is aimed. The X2 employs two red laser dot sights – one steady red dot indicates where the top barb is aimed and a flashing dot where the bottom barb is aimed. A series of live firing tests were completed at different ranges to assess the accuracy and consistency of the following measurements:

- Point of Aim (POA) from red laser dot to the Point of Impact (POI) of the top barb;
- Barb spread (the measured distance between the POI of the top and bottom barbs);
- POA from flashing red laser dot to the POI of the bottom barb (X2 only).

During testing, the laser dot for the top barb was always referenced to a single POA for every shot. The test involves a number of cartridges being fired at a fixed POA at a cardboard target from different test ranges. The Tasers were fixed to a mounting rig for constancy and to minimise aiming error from hand firing.

The accuracy of the bottom barbs in relation to the POA was recorded. To assess and compare the consistency of the bottom barbs shots, the mean radius was calculated and compared to the top barb shots.

Tests were carried out using operational and training cartridges to compare their performance. In the case of the Taser X2, the left bay was the primary firing bay for measurements. Ten operational cartridges were fired from the right bay to enable a comparison to be made between the bays.

The test method employed and all the results can be found in Appendix C. The measurements taken are in centimetres unless stated to reflect the operational requirements (see Appendix A). A tolerance of +/- 0.5 cm is accepted.

Table 7 and Table 8 show the breakdown of test ranges, types of cartridge and the numbers of cartridges that were fired for the X26 and X2 respectively.

Table 7: Taser X26 test ranges and cartridges fired

Test range	21 ft operational cartridge	21 ft training cartridge
1.5 m (5 ft)	10	10
3.0 m (10 ft)	20	10
4.6 m (15 ft)	20	10
6.1 m (20 ft)	20	10

Table 8: Taser X2 test ranges and cartridges fired

Test range	25 ft operational cartridge		25 ft training cartridge
	Left bay	Right bay	
1.5 m (5 ft)	10	10	10
3.0 m (10 ft)	20	10	10
4.6 m (15 ft)	20	10	10
6.1 m (20 ft)	20	10	10
7.6 m (25 ft)	10	10	10

A high-speed camera was used to measure within the velocity of the barb probe over the first 30 cm from muzzle.

The operational requirement CED-OR(TE)-09 for the operational cartridges states that the effective range of the CED will be commensurate with the maximum distance a subject could cover in an officer's reaction time. This varies from 0 to 6.1 m (0 to 21 ft). To test this requirement, 30 operational cartridges were fired at a target board 6.1 m (21 ft) from the front of the cartridge. To meet the requirement, the top and bottom barb must impact the target board. The test was repeated using training cartridges to ensure comparable performance.

The standard X26 barbs are secured to the wire by a tied knot. The wire is secured to the SP barb by being trapped under the plastic end cap. To assess how well the wire is secured, five live cartridges were fired at a cardboard target greater than 7.6 m (25 ft) away.

3.4.2 Summary

3.4.2.1 Accuracy and consistency results

Table 9 summarises the results showing the average x and y coordinates of the POI compared to the laser dot POA for the top barbs at all ranges for the X26 and X2 so they can be compared. Table 9 also shows the same measure for the X2 bottom barbs in relation to the bottom laser dot POA. The table also shows the minimum, maximum, range and average barb spread between the POI of the top and bottom barbs for both CEDs.

Examining the results in Appendix C, it can be seen that the accuracy of the top barbs from the operational cartridges fired from the X2 showed an improved level of consistency compared to the X26. The grouping of the X2 top barb shots were more consistent around the mean point of impact and less outlying shots were observed. This result is reflected in Table 10 which shows the mean radius and maximum radius of the top barb shots fired from the X2 are less than the X26. Beyond 10 ft, the X2 bottom barbs show a downward spread tendency from the POA, whereas the X26 bottom barbs can be seen to maintain elevation but drift towards the left of centre.

Observing the drop in the mean point of impact (MPI) from the POA of the top barb at 3.0 m (10 ft), 4.6 m (15 ft) and 6.1 m (20 ft) the X2 was seen be consistent when compared with the X26 showing a variation in drop of 2.7 cm, 2.6 cm and 2.5 cm respectively.

The barbs fired from the X26 cartridge deploy at an angle of 8°, whereas for the X2 it is 7°. Comparing the average barb spread of the X2, this 1° variation showed a reduction of 0.5 cm, 2.7 cm, 7.2 cm and 6.8 cm less than the X26 at the test ranges between 1.5 m (5 ft) and 4.6 m (20 ft) respectively.

Table 9 also shows that at 5 ft the maximum barb spread recorded was below the minimum recommended barb separation distance of 30 cm for the X26 and X2 to achieve NMI as explained earlier in 3.4.1[7].

Table 9: Summary of average test results comparing the X26 and X2

Taser model	Test range	Top barb POA to MPI (top laser) (cm)		Bottom barb POA to MPI (bot laser) (cm)		Barb spread (cm)			
		X	Y	X	Y	Min	Max	Range	Avg
Taser X26 (2015 test)	1.5 m (5 ft)	-0.2	3.6			19.3	24	4.7	20.9
	3.0 m (10 ft)	-1.2	2.0			33.4	44.5	11.1	40.3
	4.6 m (15 ft)	-3.1	-4.4			50.5	65	14.5	58.2
	6.1 m (20 ft)	-2.2	-14.0			66.4	85.5	19.1	76
Taser X2 (left bay)	1.5 m (5 ft)	-0.1	2.7	-2.2	0.9	18.7	22.0	3.3	20.4
	3.0 m (10 ft)	-0.6	-0.7	-2.2	-1.8	30.3	44.5	14.2	37.6
	4.6 m (15 ft)	0.3	-7.0	-2.2	-4.2	39.6	64.7	25.1	51.0
	6.1 m (20 ft)	0.3	-16.5	-2.5	-14.0	59.3	83.2	23.9	69.2
	7.6 m (25 ft)	0.35	-28.2	-1.0	-25.1	77.0	105.0	28.0	86.2

Further analysis of the accuracy and consistency of the X2 was conducted against the requirement during the lab tests. Further details and the results can be seen in Appendix C.

The requirement CED-OR(TE)-08 assesses the accuracy and consistency of the top barb (20 shots) at 3.0 m (10 ft), 4.6 m (15 ft) and 6.1 m (20 ft) ranges by carrying out the following measurements and assessing the results against the requirement. Additional shots (10) were also taken at 1.5 m (5 ft) and 7.6 m (25 ft) for supplementary information.

- Measuring the MPI compared to the POA which is the laser dot.
- Determining the consistency where a minimum of 50% of shots must be within the mean radius of 20 shots.
- Calculating the maximum radius of 20 shots.

The X2 operational and training cartridges met all of the requirements for consistency and accuracy.

The mean and maximum radius measurements of the groups of shots in relation to the MPI are explained in the next paragraph. The measurements (see Figure 11) from the X2 shots can be compared to the performance of the X26 and shown in Table 10. The 1.5 m (5ft) range was considered to be too close without offering notable data and only ten shots were taken at this range for comparison purposes so this distance was omitted from the operational requirement.

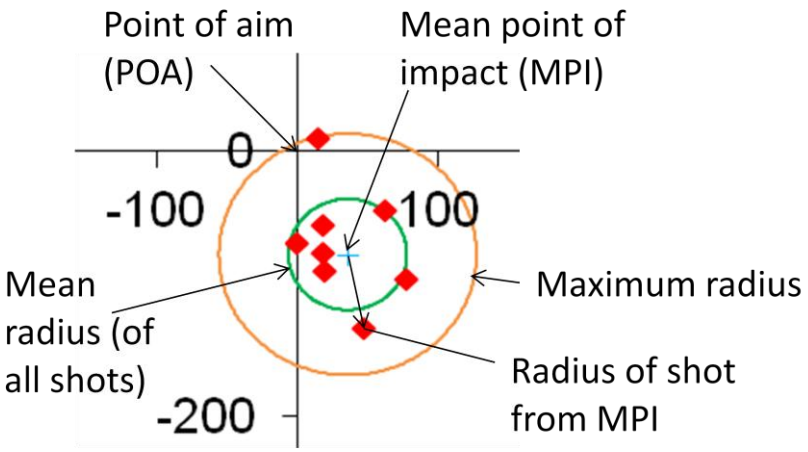


Figure 11: Measurement example

Point of aim (POA) – where the laser sight is aimed

Mean point of impact (MPI) – the mean of the x and y coordinates, e.g. the centre of the group of shots

Radius of shot – the distance from the MPI to the impact point of shot, e.g. R1, R2, R3

Mean radius – the average distance of all the shots from the MPI

Maximum radius – the maximum distance of all the shots from the MPI

Table 10 Comparing mean and maximum radius of top barb shots for the X2 against the X26 (in cm)

Measure	Test range	CED cartridge type		
		X26 ops	X2 ops	X2 training
Mean radius	1.5 m (5 ft)	1.9	0.5	1.3
	3.0 m (10 ft)	3.3	2.7	2.7
	4.6 m (15 ft)	3.7	3.0	3.0
	6.1 m (20 ft)	7.4	5.2	8.2
	7.6 m (25 ft)	Out of range	5.6	5.1
Maximum radius	1.5 m (5 ft)	5.3	1.3	2.6
	3.0 m (10 ft)	7.6	7.8	8.9
	4.6 m (15 ft)	8.0	8.1	5.0
	6.1 m (20 ft)	13.8	9.5	16.7
	7.6 m (25 ft)	Out of range	10.5	9.3

Mean radius:

Mean radius = $n\sum ri/n$

where $ri = SQRT\{ (xi – xc)2 + (yi – yc)2 \}$

(xi , yi) are the shot coordinates and (xc , yc) are the MPI coordinates.

Maximum radius:

$$\text{Maximum radius} = \text{MAX}\ \{(xi - xc)2 + (yi - yc)2\ \}$$

3.4.2.1 Bottom barb accuracy utilising the X2 dual laser sights

Officers' familiarity with the X26 and the natural line of sight leads to a tendency for the POA to be primarily targeted using the top laser. The X2 dual laser sight aids the user in bottom barb placement. Table 11 shows the actual distance measured between the top and bottom lasers (POA) compared to the average of the measurement of barb spread between the impact points of the top and bottom barbs. The results indicate that comparing POA indicated by the dual laser sights with the average barb spread of the top and bottom barbs varies between only 1.3 cm to 3.8 cm depending on the firing distance with 3.0 m (10 ft) being most accurate.

Table 11: Comparing the accuracy of the X2 laser sights with actual barb separation

X2 barb spread (left bay, ops cartridges)	Firing distances				
	1.5 m (5 ft)	3.0 m (10 ft)	4.6 m (15 ft)	6.1 m (20 ft)	7.6 m (25 ft)
Actual top to bottom laser distance (in cm)	18.4	36.3	54.2	71.8	90.0
Top to bottom barb spread after impact (average in cm)	20.4	37.6	51.0	69.2	86.2
Difference (cm)	+2.0	+1.3	-3.2	-2.6	-3.8

The results (see Appendix C) show that bottom laser dot tended to be central to the group of bottom barb shots at 5 ft, 10 ft and 15 ft. At the further ranges of 20 ft and 25 ft, the fall of shot compared to the POA was observed to increase. As an indication of the accuracy of the bottom barb impact point compared to the bottom laser POA, Table 12 shows the maximum, minimum and average distance between these two points. The same measurements for the top barbs are shown in brackets. This is a non-directional measure for indication purposes.

The results show that the distances between the top and bottom laser sights in relation to the POI are reasonably consistent at all ranges. Table 9 shows the relationship between the POA and MPI of the bottom barbs. Minus values are to the left (X) and lower (Y) than the POA.

As a further comparison of consistency, Table12 also shows the mean and maximum radius of the bottom barb shots which can be compared to the top barb (in brackets alongside). The results show that the performance of the bottom barb in relation to the laser sight is closely comparable to the top barb.

Table 12: X2 bottom barb accuracy compared to the POA; top barb measurement is shown in brackets

	Distance (in cm) between bottom barb laser POA and bottom barb impact (top barb)				
	5 ft	10 ft	15 ft	20 ft	25 ft
Maximum	3.3 (3.2)	7.4 (6.9)	14.1 (14.5)	27.2 (22.8)	33.0 (34.0)
Minimum	2.3 (2.0)	1.9 (8.0)	2.9 (2.9)	6.1 (8.0)	18.5 (17.0)
Average	2.6 (2.8)	4.3 (3.0)	6.8 (8.0)	14.8 (17.0)	25.2 (28.8)
	Bottom barb mean radius in cm (top barb)				
Mean radius	0.8 (5.0)	2.9 (2.7)	4.5 (3.0)	6.1 (5.2)	6.3 (5.6)
Maximum radius	1.9 (1.3)	5.8 (7.8)	11.0 (8.1)	13.0 (9.5)	9.1 (10.5)

Training cartridges

Training cartridges were fired from the left bay of the X2 and showed comparable performance to the operational cartridges (see Table 10).

3.4.2.1 Barb probe velocity

The velocity of the top barbs fired from the operational cartridges of X26 and X2 were measured using a high-speed camera over a distance of 30 cm from the muzzle. Table 9 shows the velocity measurements for the barb probes from the standard 21 ft X26 operational cartridge and the SP barbs from the X2 operational cartridge. Comparing the results between the X2 and X26 barb probes, the velocity range of the X2 probes is wider and the velocity is higher.

Table 13: Top barb probe velocity

Cartridge type	Velocity (m s^{-1}) 30 cm from muzzle				
	Minimum	Maximum	Range	Average	SD
Standard operational 21 ft X26 cartridges	39.1	42.0	2.9	41.1	1.05
Standard operational 25 ft X2 cartridges (SP probe)	47.8	52.1	4.3	50.2	1.02

3.5 Effective range test

3.5.1 Description

The operational requirement CED-OR(TE)-09 in Appendix A states that the effective range of the CED will be commensurate with the maximum distance a subject could cover in an officer's

reaction time. This varies from 0 to 6.1 m (21 ft). To test this requirement, the range of the device will be tested to ensure that the range is at least 21 ft.

Thirty of the X2 operational cartridges were fired by the CED secured in a fixed mount at a fixed person-sized target at a distance of 21 ft (6.4 m). The requirement is for both the top and bottom barbs to impact the target. This was repeated for the X2 training cartridges.

To assess how securely the wires were fixed to the new SP barbs, an extended range test was carried out by firing five X2 operational cartridges at a target range in excess of 30 ft.

3.5.2 Summary

When 30 operational cartridges and 30 training cartridges were fired from the X2, all of the top and bottom barbs impacted the target at 6.1 m (21 ft).

When fired at a target beyond 7.6m (25 ft), none of SP barb probes detached from the wire.

3.6 EMC test

3.6.1 Description

The Operational and User Requirement OR(TE)-07 in Appendix A states that the CED shall not affect the effective operation of police communications devices, or the local infrastructure (including the mobile phone network), and comply with the latest EMC standard.

In May 2014, the Automotive and Equipment Section (AES), part of Home Office Science CAST carried out a de-risk assessment of the Taser X2 in accordance with AES Conformance Specification 5, which tests against the requirement. The test also included the Taser X26P.

The purpose of the assessment was to determine the electromagnetic compatibility (EMC) and mutual interference (MI) characteristics of the equipment under test (EUT), namely the Taser X2 and X26P.

The test report and results can be found in the references[10].

3.6.2 Summary

The results from the tests carried out by AES determined that neither the X2 nor the X26P suffered from or caused EMC problems when armed within the body-worn environment of a police officer.

The report concluded that the units under test (X2 and X26P) complied with the requirements laid down within AES Specification 5, issue 11.

AES recommend that due to the high voltage levels generated during application of the firing mechanism, a separation distance of at least 2 m is maintained between a receiving TETRA radio and the firing unit. This is necessary to reduce the effect of very high transient (switching) pulses radiating from the unit under test being fed into the TETRA body-worn radio antenna port and would apply to the X26, X2 and X26P CEDs only while the Taser cycle is in operation.

CAST is not aware of this effect being an issue with the X26. Any effects to the receiver would only occur while the Taser is firing and would not be permanent.

4. User handling trial

4.1 Introduction

Between 6 and 8 April 2016, CAST conducted a user handling trial at a Metropolitan Police Taser Training Facility to assess the handling characteristics of the TASER International X2 CED. The X26 was also used by selected groups as a comparison. The trials involved volunteer police officers who participated in 13 scenario-based exercises. At the end of the exercises the participants completed a questionnaire to establish their views on the CED they had used in the trials.

4.2 Participating officers

Eighteen officers from three UK police forces participated in the trials. The participating officers, both male and female, had a range of lengths of service and Taser-trained experience, within groups of 0 to 5 years, 5 to 10 years, and over 10 years as shown in Table 14. The participating officers comprised of three groups of six officers. The three groups were: Authorised Firearms Officers (AFO), officers from Specially Trained Units (STU) and New Users (NU). The AFOs and STUs were X26 Taser trained and assessed to the same national standards in both accuracy and handling, although both groups may have had additional training in role-specific tactics.

Authorised Firearms Officers (AFOs):	AFOs are authorised and trained to deploy operationally with the Taser X26 (and other firearms).
Specially Trained Units (STUs):	STUs are authorised and trained to deploy operationally with the Taser X26.
New Users (NUs):	NUs do not have any previous experience or training with CEDs. They will not have any pre-conceived ideas from already having used the X26 Taser that is currently in service with UK police

During the trials, the three groups of officers experienced using the X2 for the first time. At the end of the exercises all three groups completed the questionnaire in Appendix E where CED 1 refers to the X2. The AFOs and STUs also completed another copy of the same questionnaire to capture their views on the X26 as a comparison. The questionnaire (Appendix E) was identical except that CED 1 referred to the X26 and Question 15 was omitted because it related to the auto-shut-off feature that is not present in the X26. To determine officer preference, the AFOs and STUs completed two additional questions at the end of the questionnaire:

Q18. Overall which model did you prefer?

Q19. Overall which model did you like least?

Table 14: Mix of officers participating in the handling trial

Taser trained and gender	No.	Length of service	No.	Experience as Taser trained	No.
Male Taser Trained	7	15+ years	5	10+ years	2
Female Taser Trained	5	10-15 years	6	5-10 years	5
Male Non-trained	3	5-10 years	2	0-5 years	5
Female Non-trained	3	0-5 years	5	0 years (NU)	6

The AFOs and STUs were all already trained in the use of the Taser X26 but were given introductory training in the use of the X2. The NUs were provided with training on the X2. The training was provided by a Taser Instructor from the College of Policing who has completed the TASER International Master Instructor Course that included the X2.

The training consisted of an introductory talk followed by practical drills. After initial training and before taking part in the exercises the officers were given the opportunity to fire one or two cartridges from each Taser model.

At the beginning of the trials each model of Taser was marked HT1 - 8 and assigned a new battery marked HTA-H. A spark test and data download was carried out on each unit before the start of the trials to check the condition of the weapon and to provide a benchmark log entry in the data download. The battery and Taser combination remained the same through the duration of the user handling trials. At the end of the trials a data download was carried out and the usage and battery levels were determined. This information may be used as an indication of battery life use during a training event. The results can be seen in Section 4.6.3.

4.3 Handling trial schedule

The handling trial took place over a period of two separate days and followed the schedule shown in Table 15 with the officers attending in their groups. The AFOs and STUs completed the trials on the same day but stayed in their specific groups throughout all of the exercises. They began the day with some introductory training before conducting the trial with the Taser models. At the end of the trial each group completed a questionnaire and in the case of the AFOs and STUs were asked an additional two questions; which model they preferred and which model they liked the least.

Table 15: Handling trial schedule

Group	Day 1	Day 2
AFO	X2 training;X26/X2 trials; questionnaire	
STU	X2 training;X26/X2 trials; questionnaire	
NU		X2 training; X2 trials; questionnaire

4.4 Aim of the user handling trials

The trials aimed to assess the X2 against the operational requirements included in Appendix A. Earlier work[2] in assessing the handling characteristics of the Taser X26 incorporated the less-lethal weapons (LLW) operational requirement that was valid in 2005 and the seven points listed below. None of these points are specifically stated in the operational requirement in Appendix A but are still considered to be valid requirements with regards to CEDs. Applying them in this trial allows any observations to be recorded and an up-to-date comparison between the X26 and the X2 to be made.

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

3. **Mobility/flexibility:** The option should be effective against a moving target. It should be easily transported to the scene of an incident, and ideally portable at the scene.

4. **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 or several)?

5. **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)?

6. **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?

7. **Durability:** How robust is the equipment required for an option? Over what period can an option be said to be reliable – what checking is required?

The holsters or method of carriage were not assessed as part of this trial. This is because there are likely to be a variety of different types of holster and methods of carriage depending on the officer's role and personal preference between officers.

4.5 Exercises

The exercises carried out in previous work[2] have been revised and updated in consultation between CAST, the College of Policing, and the Metropolitan Police Lead Taser Trainer to address the operational requirements and include current UK Taser training practices. For example, in previous tests the participating officers may have been instructed to aim at the upper torso. During these handling trials, all of the participating officers were instructed, as they would be in Taser training, to "aim to achieve one probe above and one probe below the belt line" when aiming. In the case of the AFOs and STUs, this instruction was familiar to the officers' current training so no additional instruction was necessary. Table 16 on page 44 summarises each of the exercises.

Four police Taser instructors, who had completed the TASER International X2 Master Instructor Course, supervised the exercises and firing lanes during the user handling trials. The

same four instructors were present throughout the trials to ensure consistent instruction was given to the participating officers.

The participating officers remained in their groups working through the exercise, repeating each exercise three times. Eight X2s and eight X26s were used between the groups. After each exercise, the AFOs and STUs alternated between starting with the X2 and X26.

To accommodate the differences between the models' operation, Exercises 5, 12 and 13 were varied slightly. The number of shots in Table 16 refers to individual single shots for the X26 and the number of bays for the X2, where bay 1 signifies one shot and 'both' signifies two shots (one from each bay). The loaded, ready position is defined as having the Taser loaded, drawn from the holster and pointing safely down range, but not raised at the target.

Exercise 5 was the moving advancing target exercise. Due to the X2 being fitted with auto-shut-off battery options (APPM), this exercise was modified in order for the officers to experience and react to this feature and answer the relevant question in the questionnaire (Appendix E, Question 15).

Exercise 12 was the angled drive stun exercise for the X26. For the X2, the taught technique is to carry out a cross-connect (explained in Section 2.7) where both cartridges are fired twice to achieve a larger barb separation.

Exercise 13 is the show of strength exercise. To arc the X26, the cartridge must be removed first to avoid firing it. However, by pressing the arc switch, the X2 can be sparked while still loaded with live cartridges.

Figure 12 shows firing from the defensive position (Exercise 2). From this position the officer moved to a standing position while the Taser was still cycling.

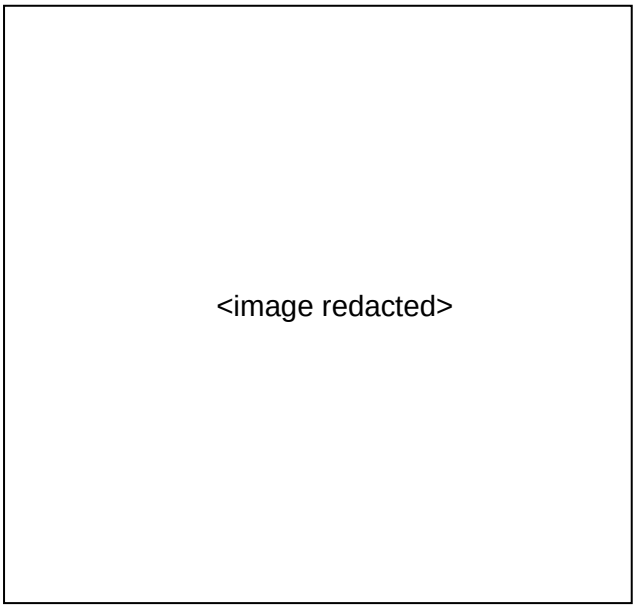


Figure 12: Defensive position

Table 16: Summary of exercises for the X2 and X26

Exercise #	Exercise description	Position of firer	Position of target	Distance from target	Ambient light	Status of taser	Laser sights used?	No. of shots/bays	Repeat
1	Standard upright	Stationary; Upright	Stationary, face on	Feet at 4 m	ON	Loaded, ready position	YES	Two/both	Three times
2	Defensive position	Stationary; Defensive position, fire, stand up	Stationary, face on	4 m (sitting position)	ON	Loaded, ready position	YES	Single/bay 1	Three times
3	Torch and in low light	Stationary; Upright, reload in the dark	Stationary, face on	Feet at 4 m	OFF in low light	Loaded, ready position	YES	Single/bay 1	Three times
4	Target moving sideways	Stationary; Upright	Moving (sideways), face on	Feet at 4 m	ON	Loaded, ready position	YES	Single/bay 1	Three times
5	Target moving forwards	Upright; Stationary	Advancing, face on and re-energise if not incapacitated	9 m (start)	ON	Loaded, in holster	YES	Single/bay 1	Three times
6	Iron sights (laser off)	Stationary; Upright	Stationary, face on	Feet at 4 m	ON	Loaded, ready position	NO	Single/bay 1	Three times
7	Target lying horizontal – no laser	Stationary; Upright	Stationary, lying on floor	Feet at 4 m	ON	Loaded, ready position	NO	Single/bay 1	Three times

Exercise #	Exercise description	Position of firer	Position of target	Distance from target	Ambient light	Status of taser	Laser sights used?	No. of shots/bays	Repeat
8	Target lying horizontal	Stationary; Upright	Stationary, lying on floor	Feet at 4 m	ON	Loaded, ready position	YES	Single/bay 1	Three times
9	Target too close	Stationary; Upright, close up and step back, firing from the hip	Stationary, face on	1 m (front foot)	ON	Loaded, ready position	YES	Single/bay 1	Three times
10	3 shot	Stationary; Upright	Stationary, face on	Feet at 4 m	ON	Loaded, ready position	YES	Three/both; Reload third from a bench	Three times
11	Shield	Stationary; Upright, behind dummy & aiming around Met riot shield	Stationary, face on	Feet at 4 m	ON	Loaded, ready position, aimed	YES	Single/bay 1	Three times; Alternate R/H & L/H with reload strong hand first
12	Angled drive stun (x26) Cross-connect (X2)	X26 – close-up probe deployment then angled drive stun X2 – close-up probe deployment then take second shot	Stationary, face on	Feet at 1 m	ON	Loaded, ready position	YES	Single/ both	Three times

Exercise #	Exercise description	Position of firer	Position of target	Distance from target	Ambient light	Status of taser	Laser sights used?	No. of shots/bays	Repeat
13	Show of strength	Show of strength	Stationary, face on	Feet at 4 m	ON	X26 – loaded, ready position on aim red dot, unload cartridge, arc, reload, fire X2 – loaded, ready position on aim red dot, arc, fire	YES	Single/bay 1	Three times

The target was a flat human shape and a modification of the same target used in Taser training. Figure 13 shows the body map target which was marked up into zones in the same layout as the Taser Deployment Forms[11] used by the UK police. These zones are used to identify the area of barb impact on a subject following an operational deployment. For the purposes of the user trial, the two larger zones covering the torso, zones 7 and 8, were split into four further sub-zones 7A-D and 8A-D to more accurately record the area of barb impact. This target was used in all of the exercises except exercises 4 and 5 (the moving target exercises). For these, a person in a protective suit was used along with the non-conductive, blue training cartridges (see Table 5 on page 22).

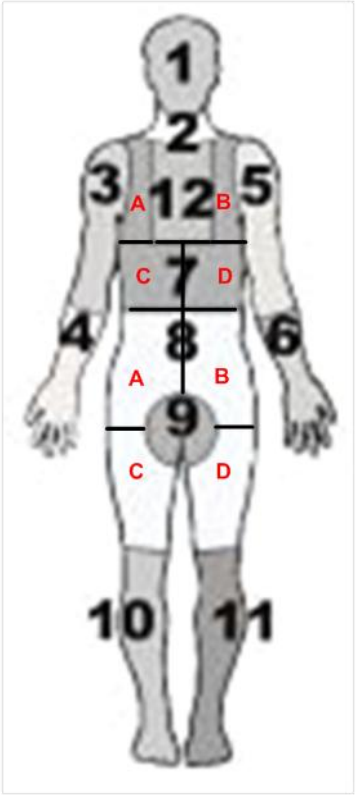


Figure 13: Body map target layout

For each shot, the impact locations of the top and bottom barbs were captured. The full results for each exercise are shown as bar charts in Appendix D and separated into the Taser-trained group (AFO/STU) and non-Taser-trained group (NU). Note that the results reflect that there are twice as many shots for the Taser-trained group as it was comprised of two groups of six officers, the AFO and STU groups. The results show the percentage of both barbs hitting the target, the number of times only one barb hit the target (therefore one miss) and the number of shots where both barbs missed the target. The results are summarised in the next section.

4.6 Summary of results from the user handling trial

4.6.1 Summary of results based on the exercises

This section summarises the accuracy and the time to fire results for the exercises carried out during the handling trials, detailing any apparent trends. The accuracy tables include the percentage of both barb hits to the body and as well as indicating, in brackets, a breakdown of the number of shots where either both barbs missed the target, one barb missed the target or ‘bounced’ out of the target, and where one barb hit the neck or head. Though no specific

training instruction was given to avoid shots to the groin area, they were noted. The results of the individual exercises can be found in Appendix D, where the groups are separated into Taser experienced (AFO and STU) and non-experienced (NU).

4.6.1.1 Results for taking two shots at a stationary target using the laser sights (Ex. 1)

Exercise 1 was carried out using the laser sight and taking two shots at an upright stationary target. The X26 requires reloading, whereas the X2 has two cartridge bays. Figure 14 shows the mean, maximum and minimum timings for each group using each of the Taser models.

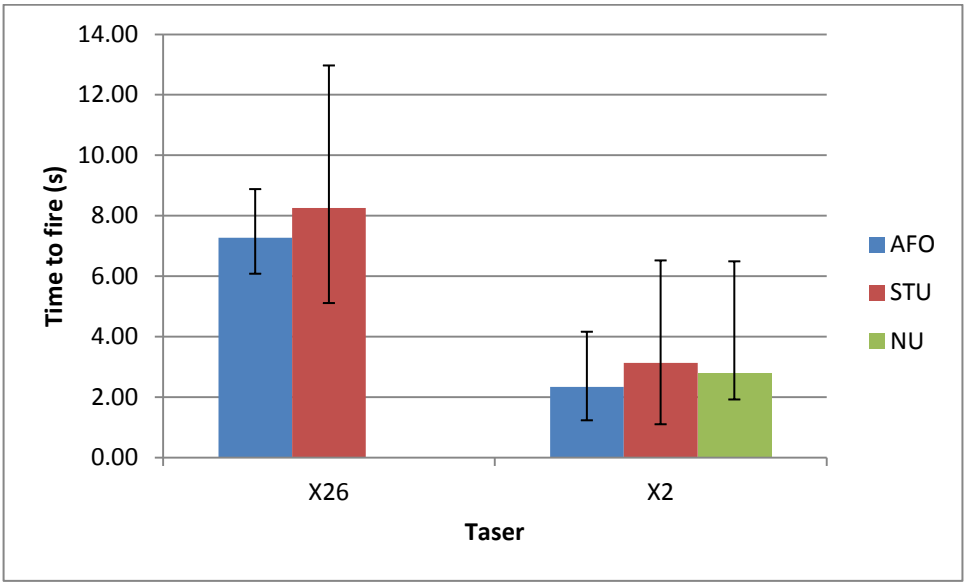


Figure 14: Time taken to fire two shots for Exercise 1

The results show that compared to the X26 the X2 was twice (if not more) as quick when taking two shots for the AFO and STU groups. The AFO and STU groups had similar timings when using each of the models; however, it was seen that the STUs had a greater range of times when using the X26. The NU group was seen to have similar timings for the X2 as the AFO and STU groups, indicating the ease of use when two shots are required.

4.6.1.1 Results for stationary targets in normal conditions with and without the use of the laser sights (Ex. 1 and 6)

Normal conditions were considered to be where the officer is standing upright facing a stationary target. Exercise 1 was carried out using the laser sight, whereas Exercise 6 was without the laser sight. Both exercises were carried out in the same ambient lighting conditions. Two shots were taken in Exercise 1 and one shot taken in Exercise 6 with a summary of accuracy shown in Table 17.

Table 17: Percentage of shots hitting the body (also one hits, both miss and bounce outs) for Exercise 1 and 6

	Laser sight on (Ex. 1)		Laser sight off (Ex.6)	
	AFO/STU (% body hits)	NU (% body hits)	AFO/STU (% body hits)	NU (% body hits)
X26	91% (6 one hit)		94% (2 one hit, 3 head, 1 neck, incl 1 bounce)	
X2	100%	100%	94% (2 one hit)	89% (2 one hit)

Interestingly the AFO and STU groups were seen to improve the percentage hits when using the X26 with the laser sights off, although overall accuracy was also affected. The AFO and STU groups recorded a significant number of groin shots (16) when using the X26 in Exercise 1 (laser sights on) with an overall accuracy of 91%. There was a slight improvement in overall accuracy (94%) when using the X26 without laser sights; however, there were three head, one neck and seven groin shots recorded. In comparison, the X2 was seen to perform much better, with 100% accuracy for all user groups when using the laser sights, although there were still a number of groin shots (14 AFO and STU, 6 NU). Although the overall accuracy for this model was lower without the laser sights, the number of groin shots was reduced (11 AFO and STU).

4.6.1.1 Results for firing from a defensive position (Ex.2)

Exercise 2 placed the officer on the floor in the defensive position (Figure 12 on page 43). The Taser was drawn and on command the officer fired at an upright target and got to their feet while the Taser was cycling. The laser sights were on.

Table 18: Percentage of shots hitting the body (also one hits and both miss) for Exercise 2

	Defensive position (Ex. 2)	
	AFO/STU (% body hits)	NU (% body hits)
X26	92% (3 one hit)	
X2	97% (1 one hit)	94% (1 one hit)

The X2 was seen to be more accurate, with a reduction in groin shots seen. A total of 12 groin shots were recorded using the X26 compared to seven using the X2. The X2 was marginally better at achieving both barb hits for all groups. The NU group was seen to have the least amount of groin shots, with an accuracy level only marginally below that of the experienced officers.

4.6.1.1 Use of Tasers in low-light conditions

Exercise 3 was carried out in low-light conditions using an upright stationary target. The laser sights and the LED flashlight were switched on.

Table 19: Percentage of shots hitting the body (also one hits and both miss) for Exercise 3

	Low light (Ex. 3)	
	AFO/STU (% body hits)	NU (% body hits)
X26	97% (1 one hit)	
X2	97% (1 one hit)	100%

Table 19 shows that the AFO and STU groups performed the same with the X26 and X2; however, fewer groin shots were recorded for the X2 (17 for X26, 10 for X2). The NU group recorded 100% for both barbs hitting, with seven groin shots. This agreed with the questionnaire responses that the CED would be suitable for use in the dark or subdued lighting conditions (CED-OR(TE)-03).

4.6.1.1 Use of Tasers against moving targets (Ex. 4 and 5)

Two exercises tested the Taser models against a moving target. In Exercise 4, the target moved from behind a screen into a gap the width of a doorway, before continuing to move sideways behind a screen on the other side. The officer had to fire the Taser at the target when it was visible. In Exercise 5, the target started at 9 m (30 ft) from the officer, which is out of range of the Taser. On command the target advanced towards the officer at a steady pace. The officer drew the Taser from the holster and fired when they judged the target to be in range and had become a threat. The shot location was recorded and a summary of the results are shown in Table 20. When the target was hit they stopped, and the distance from the officer to the target was recorded and is shown in Figure 15.

Table 20: Percentage of shots hitting the body (also one hits and both miss) for Exercises 4 and 5

	Target moving sideways (Ex.4)		Target moving forwards (Ex.5)	
	AFO/STU (% body hits)	NU (% body hits)	AFO/STU (% body hits)	NU (% body hits)
X26	83% (6 one hit, incl 1 bounce)		81% (7 one hit, incl 5 bounces)	
X2	94% (2 one hit)	100%	94% (1 one hit, 1 both miss incl. 3 bounces)	100%

In both cases the X2 was seen to be the most accurate. The X26 performed marginally better when the target was moving sideways rather than advancing, with a number of barbs seen to bounce off the advancing target (in most cases hit location unknown, therefore counted as a one hit). A greater number of groin shots were seen for the sideways target (total of ten compared to two for the advancing target) for the X26. This trend was also seen for the X2 where ten groin

shots were recorded for the sideways target compared to two for the advancing target. The NU group was seen to have the greatest level of accuracy with 100% and no groin shots recorded.

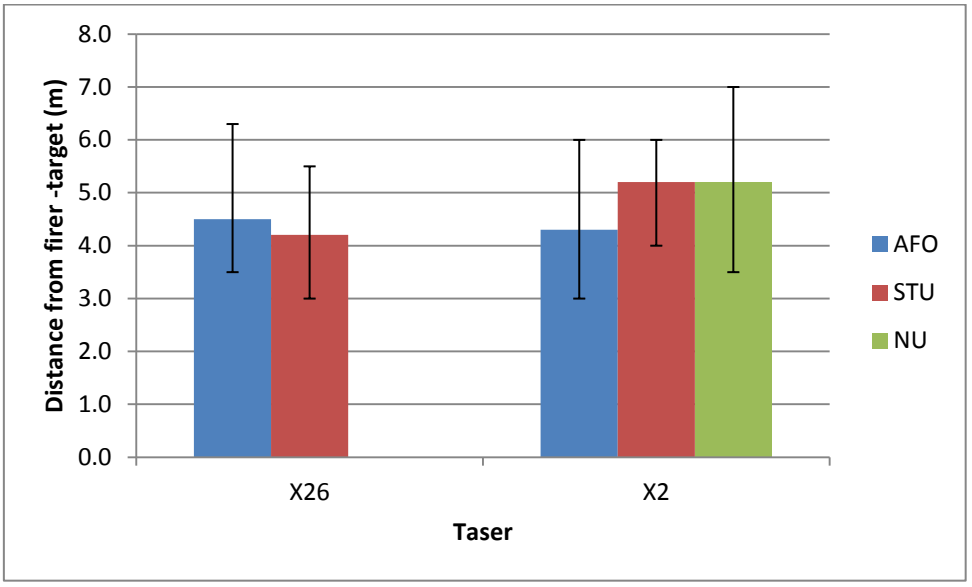


Figure 15: Mean, minimum and maximum distance between the firer and target after shot was taken in Exercise 5

In Exercise 5 the AFO group was seen to fire at a similar distance to the target, at around 4.5 m for both models. Conversely, the STU group was seen to fire at a greater distance with the X2, at just over 5 m compared to 4 m for the X26. The NU was also seen to fire at a greater distance, similar to the STU group. Firing at a greater distance with the X2 may have been the result of utilising the dual laser to provide confidence in being able to indicate the POA for both barbs on the target.

In Exercise 5 the groups reactivated the X2 when the APPM had stopped the Taser cycle after five seconds. The mean, maximum and minimum distances from the firer to the target when the X2 was re-energised are shown in Figure 16.

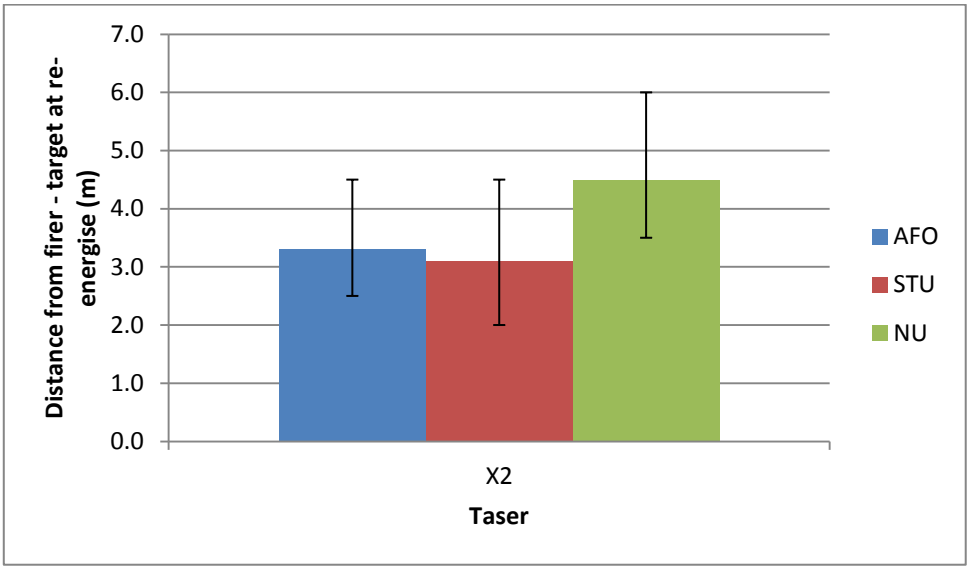


Figure 16: Maximum, minimum and mean distance between the firer and target after Taser is re-energised in Exercise 5 (X2 only)

The results show that the AFO and STU groups re-energised at similar distances, around 3 m from the target. Conversely, the NU group was seen to re-energise at a greater distance from

the target at around 4.5 m. When compared to the initial shot, this indicates that the NU re-energised fairly quickly once the target began to advance again.

4.6.1.1 Use of the Tasers against targets lying down with and without using the laser sights (Ex. 7 and 8)

Exercises 7 and 8 involved the officers firing each of the Taser models at a human-shaped target that was lying horizontally on the ground. This exercise was carried out with and without the laser sights. The officer was expected to cant the Taser in the correct orientation to achieve a successful two barb hit on the target. The summary of the results are shown in Table 21.

Table 21: Percentage of shots hitting the body (also one hits and both miss) for Exercise 7 and 8

	Target lying sideways, laser sights off (Ex. 7)		Target lying sideways, laser sights on (Ex.8)	
	AFO/STU (% body hits)	NU (% body hits)	AFO/STU (% body hits)	NU (% body hits)
X26	83% (5 one hit, 1 both miss, 1 head, 1 neck)		86% (5 one hit)	
X2	86% (5 one hit)	78% (4 one hit)	89% (3 one hit, 1 both miss)	67% (6 one hit)

This exercise provided a demonstration of the challenges in shot placement when the Taser had to be canted, and making the allowance for the drop in the barbs in the horizontal plane. Even with the X2 dual laser sights, no significant difference was noted between the X26 for the AFOs and STUs. With the laser sights off, a head, neck and seven groin shots were recorded for the X26 and 13 groin shots for the X2. There were two shots where both barbs missed, one from the X26 and one from the X2, both from the AFO group.

Unsurprisingly the results from the NU group had a lower successful hit percentage that the ARO/STU group for this exercise, but interestingly this improved when the laser sights were off rather than on. This could be due to the need to cant the Taser and the drop of the barbs in the horizontal plane mentioned earlier; which is a technique a new user would not have received training in.

4.6.1.1 Reloading the Tasers – 3 shots (Ex. 10)

In Exercise 10 the officers had to fire three cartridges in quick succession. For the X26 this entailed firstly firing the cartridge that was already loaded in the X26, then reloading from the XDPM, and loading and firing a third that was positioned on a bench next to the firer. For the X2, both bays were fired and then unloaded, and a third cartridge loaded from the bench alongside the officer and fired. The results of the hit locations are shown in Table 22.

Table 22: Percentage of shots hitting the body (also one hit and both miss) for Exercise 10

	3 shot (Ex. 10)	
	AFO/STU (% body hits)	NU (% body hits)
X26	97% (1 one hit)	
X2	97% (1 one hit)	100%

There is no difference in the accuracy seen for the AFO-STU group between the two models; however, there were slightly more groin shots for the X26 (12 compared to 11 for the X2). The NU group achieved the greatest level of accuracy and lower rate of groin shots (seven in total).

Figure 17 shows the results of the time taken by each group to fire three cartridges from each Taser model.

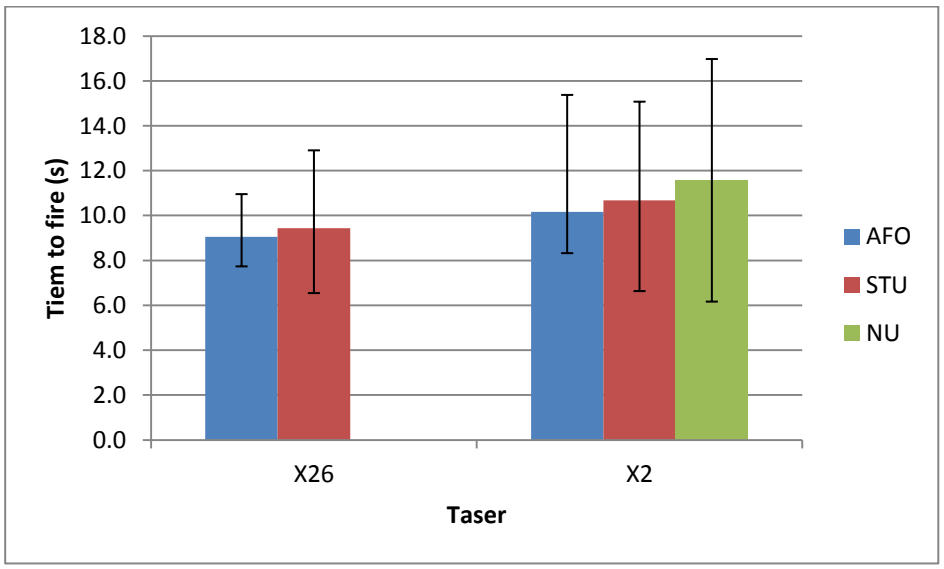


Figure 17: Minimum, maximum and mean time (in seconds) for officers to take three shots for Exercise 10

There was not a significant difference in loading and firing times for the two Taser models. The X26 was seen as marginally quicker, with the X2 taking, on average, around an additional second to reload and fire the three shots. This could be due to a greater familiarity with the X26 by the Taser-experienced officers. The speed of taking the first two shots with the X2 (approx. 3 secs.) and the difficulty experienced with reloading balances out the time for this exercise between the two devices. The NU group, as expected, took the longest; on average this was still only 2 seconds longer than the AFO and STU groups. The NU group would be likely to improve the time taken after further familiarisation, as would the AFO and STU groups.

4.6.1.1 Using the Taser around a riot shield (Ex. 11)

Exercise 11 requires the officer to fire the Taser from behind a shield that was being held by a colleague. With the Taser drawn, on command the firer aimed and fired at an upright, stationary target with the laser sights on. Table 23 shows the results.

Table 23: Percentage of shots hitting the body (also one hits and both miss) for Exercise 11

	Shield (Ex. 11)	
	AFO/STU (% body hits)	NU (% body hits)
X26	97% (1 both miss)	
X2	100%	94% (1 one hit)

The X2 obtained the highest level of accuracy, as well as the lowest number of groin shots recorded for the AFO and STU groups (13 with the X26 compared to 10 for the X2). The only shot where both barbs missed for this exercise was also recorded for the X26.

4.6.1.1 Using the Tasers against a target that is too close (including drive stun and cross-connect) (Ex. 9 and 12)

Exercises 9 and 12 examined two scenarios that involved a target who may be too close. Exercise 9 required the officer to start at a distance of 1 m from the target and, before firing, take a step backwards in order to achieve a wider barb spread. The time taken from command to taking the shot was recorded and shown in Figure 18.

Exercise 12 varied between the two Taser models. For the X26, an angled drive stun was carried out where a shot is taken and a third contact point is made by directly applying the Taser at another location in order to achieve the necessary barb spread. As the X2 has a cross-connect capability (explained in Section 2.7), one bay is fired at one location on the target and then the second shot is taken straight after. The time taken from command to the second connection was recorded and is shown in Figure 19.

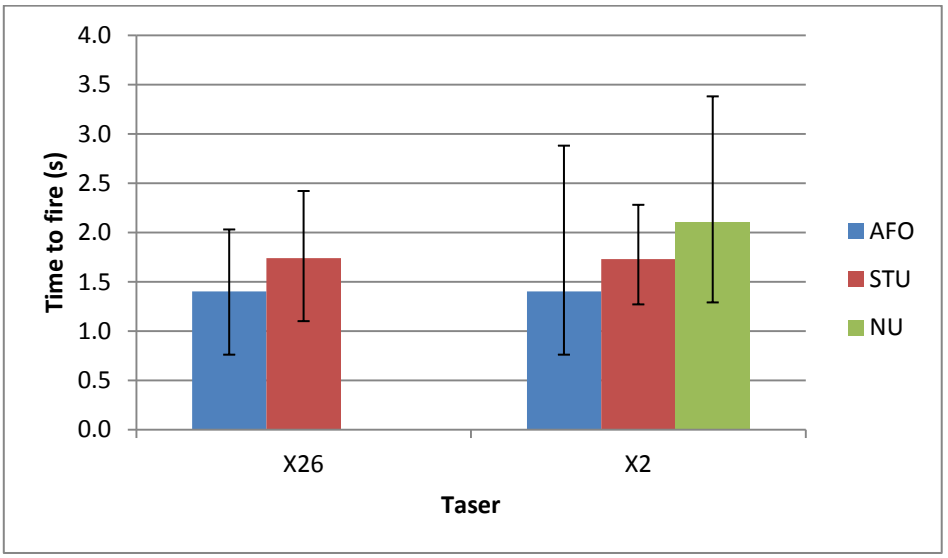


Figure 18: Minimum, maximum and mean time (in seconds) taken for officers to step back from the target and fire for Exercise 9

The results from Exercise 9 show that the AFO and STU groups on average were very similar in the times recorded, around 1.5 seconds for each model. The NU group was seen to take marginally longer (2 seconds) to complete the exercise.

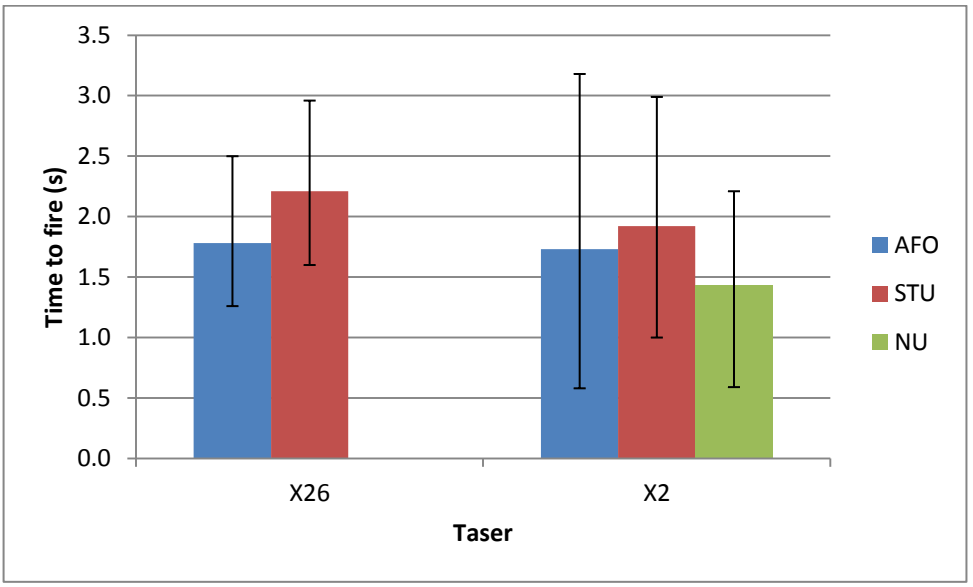


Figure 19: Minimum, maximum and mean time (in seconds) taken for officers to complete an angled drive stun (X26) and a cross-connect (X2) for Exercise 12

The results from Exercise 12 again showed very similar timings between the AFOs and STUs. The results show that it took a similar time to complete a cross-connect with the X2 compared to the X2. Interestingly the NU gained the quickest time to complete the exercise.

4.6.1.1 Results for a show of strength (Ex. 13)

In Exercise 13 the officers had to demonstrate a show of strength by arcing and then firing each model. For the X26, the officers first had to unload the live cartridge before arcing and firing. The X2 can be arced, by pressing the arc button, without having to unload the cartridges. The results are shown in Figure 20.

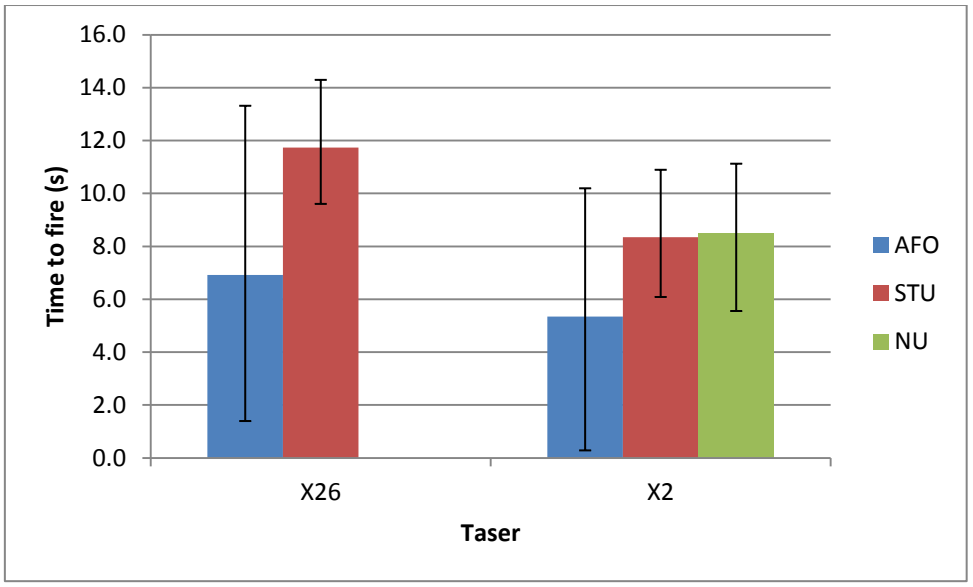


Figure 20: Minimum, maximum and mean time (in seconds) taken for officers to demonstrate a show of strength for Exercise 13

The results show that the AFOs were considerably quicker at unloading, arcing and firing the X26 than the STUs, on average approximately 4 seconds quicker. The AFOs were also able to complete the exercise in the shortest time with the X2 by approximately 3 seconds quicker

than the other groups. By not having to remove the cartridge to arc, the X2 saved almost 3 seconds.

4.6.2 Overall barb impact summary chart

Table 24 shows a summary of shots and area of barb impact with the results separated between Taser trained and experienced officers (AFO and STU) and the NU group. The number of shots includes operational and training cartridges. Head, neck and one hit correspond to single barbs. Head and neck shots are still classed as hits.

Table 24: Summary of shots and barb impacts

Taser model	Users	Total shots fired	Both hit	Head	Neck	One hit	Both miss
X26	AFO/STU	504	458 (91%)	4 (Ex. 6 & 7)	7	42	2
X2	AFO/STU	540	508 (94%)		3	33	2 (Ex 5 & Ex 8)
	NU	270	254 (94%)		1	17	

4.6.3 Taser and battery performance during the handling trial

For the handling trial, eight X26s and eight X2s were used between the AFOs and STUs. The NU group used six out of the eight X2s. The estimated date of manufacture was established from the date of the first firing log entry from the data download. The estimated date of manufacture of the X2s was 10/03/16.

The X26s used were borrowed from operational stock used for training and the estimated date of manufacture could not be established in the same way because the first entry had been over written by the number of firing log entries recorded.

At the beginning of the handling trial, each model of Taser was fitted with a new battery and a data download was carried out. Table 25 shows the battery percentage indication before and at the end of the trials. Over the course of the handling trials, the temperature range recorded in the data download of the Tasers was between 17°C and 21°C (pre-trial download) and 19°C to 28°C (post trial download).

Two of each device were shared between each group of three officers which accounts for the variation in the number of trigger pulls. The X2 serial numbers ending in 922 and 8KV were not required to be used by the NU group.

Table 25: Summary of battery performance during the user handling trial

Model	Serial number	Firmware version	Data download version	Battery level at start of trials (%)	Number of trigger pulls	Number of arc events	Battery level at end of trials (%)	Theoretical battery usage per activation (%)
X26	X00-173489	Rev. 24	3.14.37	99	101	-	65	0.34
X26	X00-174428	Rev. 24	3.14.37	99	55	-		Battery fault
X26	X00-189215	Rev. 24	3.14.37	99	103	-	62	0.36
X26	X00-278071	Rev. 24	3.14.37	99	52	-	81	0.35
X26	X00-279655	Rev. 24	3.14.37	99	64	-	78	0.33
X26	X00-289723	Rev. 24	3.14.37	95	76	-	68	0.36
X26	X00-333219	Rev. 24	3.14.37	99	104	-	64	0.34
X26	X00-741810	Rev. 24	3.14.37	99	53	-	80	0.36
X2	X300038MR	04.020	3.14.37	99	125	13	78	0.15
X2	X300038R6	04.020	3.14.37	99	145	22	74	0.15
X2	X30003948	04.020	3.14.37	99	101	13	82	0.15
X2	X300038N8	04.020	3.14.37	99	115	12	81	0.14
X2	X30003926	04.020	3.14.37	99	133	24	77	0.14
X2	X3000391A	04.020	3.14.37	99	136	23	72	0.17
X2	X30003922	04.020	3.14.37	99	99	18	82	0.15
X2	X300038KV	04.020	3.14.37	99	49	9	91	0.14

Table 25 shows that during the handling trials the indicative battery use per activation of the X2 is approximately half that of the X26. The duration of the activations varied and not all full 5 second discharges, and battery levels may vary dependent on temperature and the usage.

The X2 performed without faults and the download data were complete without errors or null entries in the firing log. The X26 performed without faults but one faulty XDPM needed to be replaced.

4.6.4 Conclusions and general comments

Over the course of the handling trial there was evidence that the X2 delivered the best accuracy compared to the X26 which may be attributed to the X2 dual laser sights. The results showed the X2 had the highest percentage of both barb hits, and the least number of head and neck hits, and both barb misses.

Between the groups and all exercises there were still a number (50) of one-barb misses using the X2, equating to 6% of the total shots fired and a marginal improvement compared to 8% for the X26.This may be attributable to users having received only fundamental training prior to taking part in the trial using the X2 and further training would possibly improve this finding.

Even the Taser-experienced officers recorded 33 one-barb misses. This data identifies the potential value of an officer having a second shot capability.

The specific benefit of the two-shot capability of the X2 was seen in the exercises where two shots had to be taken. It was found that the participants could complete this exercise in less than half the time using the X2 compared to the X26. By not having to unload the cartridge to demonstrate a show of strength and arc the X2, this exercise was completed significantly quicker than with the X26.

With the additional functionality of the X2 there was an initial expectation that the participants may have found using it more complicated compared to the simple and straightforward operation of the X26. In particular, the exercises where the arc button was used were expected to prove a challenge, since the more natural reaction would typically be to operate the trigger which would fire the cartridge instead of re-energising or arcing the X2. However, during the trial there were no such instances and no handling issues.

The X2 units used during the handling trial were found to be reliable and performed without any faults or problems. During the handling trial, one operational X2 cartridge failed to fire (see Chapter 5).

4.7 Responses to the participant questionnaires

This section collates the views provided by the 18 officers who participated in the Taser handling trials. The participants completed a questionnaire after they had completed the 13 exercises using the Taser models. The X2 questionnaire that was completed by all three groups consisted of 17 questions and is included in Appendix E. The AFO and STU groups completed an identical questionnaire relating to the X26 which had two final questions:

- Overall which model did you prefer?
- Overall which model did you like least?

A statement was given and the participants were asked to indicate whether they strongly agreed, tended to agree, tended to disagree or strongly disagreed with each statement or to indicate a “Don’t Know” response.

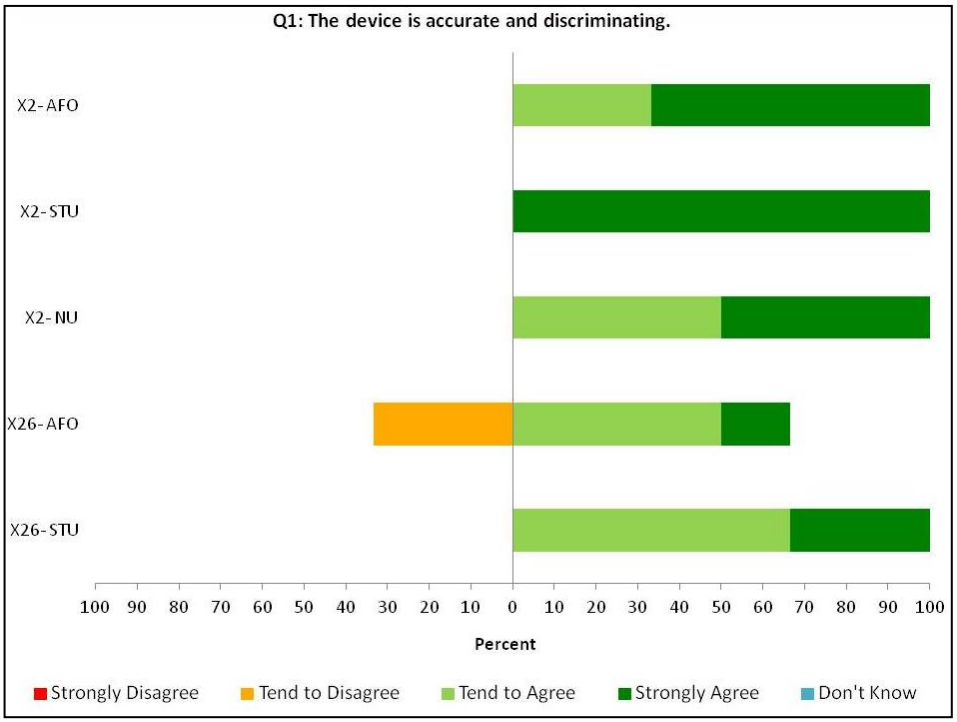
Space was left for comments to be recorded for each of these questions. A copy of the questionnaire and a summary of the responses given are included in Appendix E.

The responses to the questionnaire are shown in charts to compare the responses from the two groups of officers; those who are Taser trained and have experience (AFOs and STUs) compared to the NU group who are not.

4.7.1 Responses from all participating officers

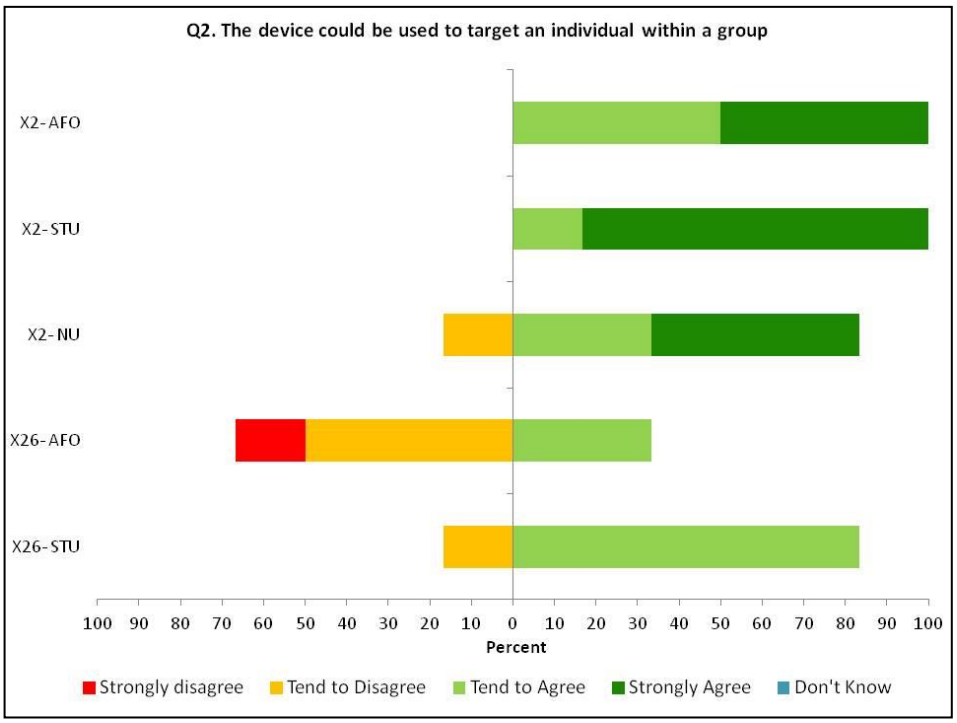
Each question is discussed individually and compares the views of the groups of officers and the Taser models.

Q1. The device is accurate and discriminating



It can be seen that 100% of the participating officers tended to or strongly agreed that the X2 was accurate and discriminating. The response showed that even though the AFO and STU groups are both trained in the X26, 33% of the AFOs thought that the X26 was not accurate. The comments from the AFOs and STUs mentioned the improved accuracy of the X2 from having dual laser sights.

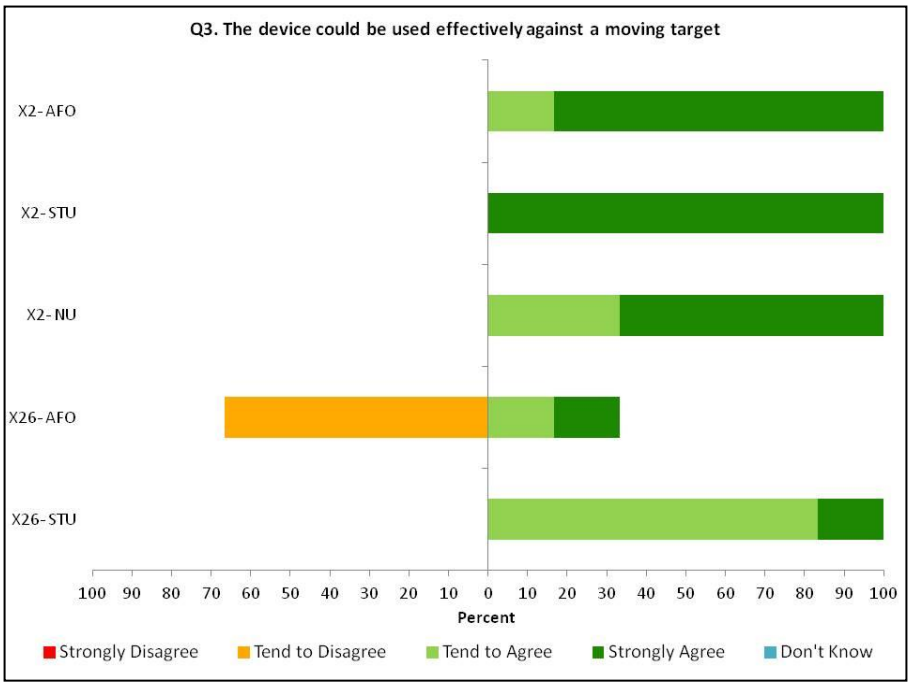
Q2. The device can be used to target an individual within a group



There was general agreement from the AFO and STU officers that the X2 is effective in this aspect; **the X2 was again indicated as the better device with 100% of AFO and STU**

officers either agreeing or strongly agreeing. The majority of NU officers also agreed that the X2 device met this requirement with only one officer tending to disagree. The majority of the AFOs disagreed or strongly disagreed that the X26 could be used to target an individual in a crowd which may be attributed to the increased confidence and accuracy of the X2 from the dual laser sights compared to the X26's single laser sight.

Q3. The device could be used effectively against a moving target (CED-OR(TE)-04)



100% of all three groups agreed that the X2 was effective against a moving target. 100% of the STUs strongly agreed that the X2 was most effective compared to only 16% for the X26. 66% of the AFOs tended to disagree that the X26 was effective against a moving target which was supported in the officers' comments that the X2 dual laser sights improved accuracy compared to the X26.

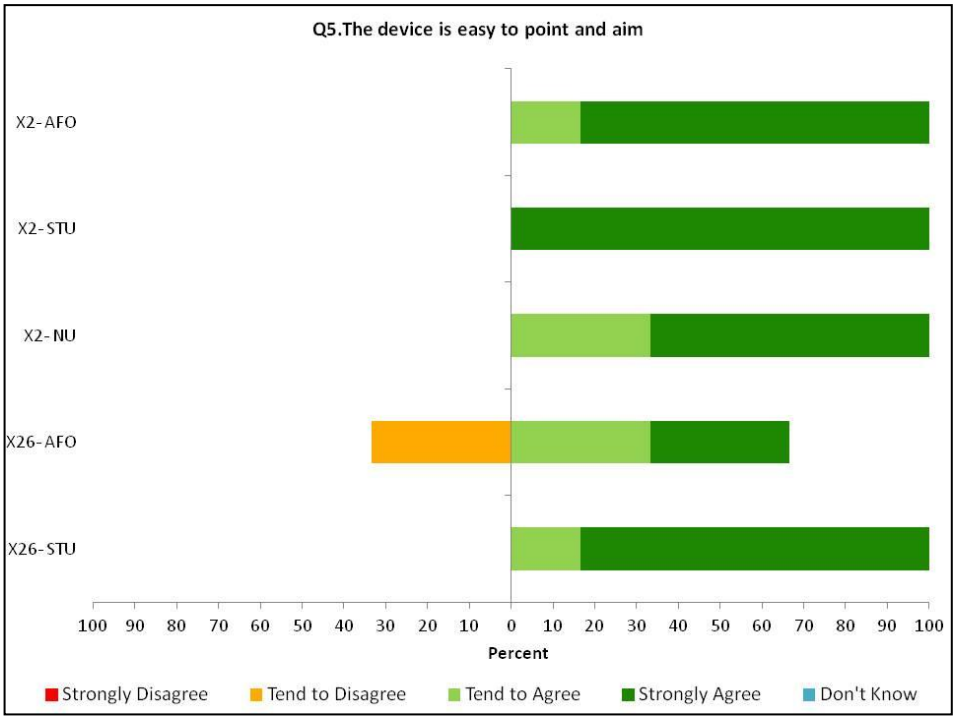
Q4. The device is appropriate for use in all officer roles

All STU and AFO officers agreed that all devices were appropriate for use in general roles (uniform response officer, AFO/ARV, PSU) with some limitations in specialist roles Two AFO officers were competent in a surveillance role and had opposing views with regards to whether the X2 was appropriate for this role; one strongly agreed and one strongly disagreed. These officers also had a mixed response as to whether they thought the X26 was appropriate for a surveillance role; one strongly agreed and one did not know. This indicates a personal preference in some cases.

One of the AFO officers, also competent in the role as a police motorcyclist, did not think the X26 or the X2 were appropriate for this role. The same officer, also competent in the role as a Close Protection Officer, thought that neither CED was appropriate for this specialist role.

The NU group comprised of uniformed response officers and two PSUs, and they all agreed or strongly agreed that the X2 was appropriate for the role.

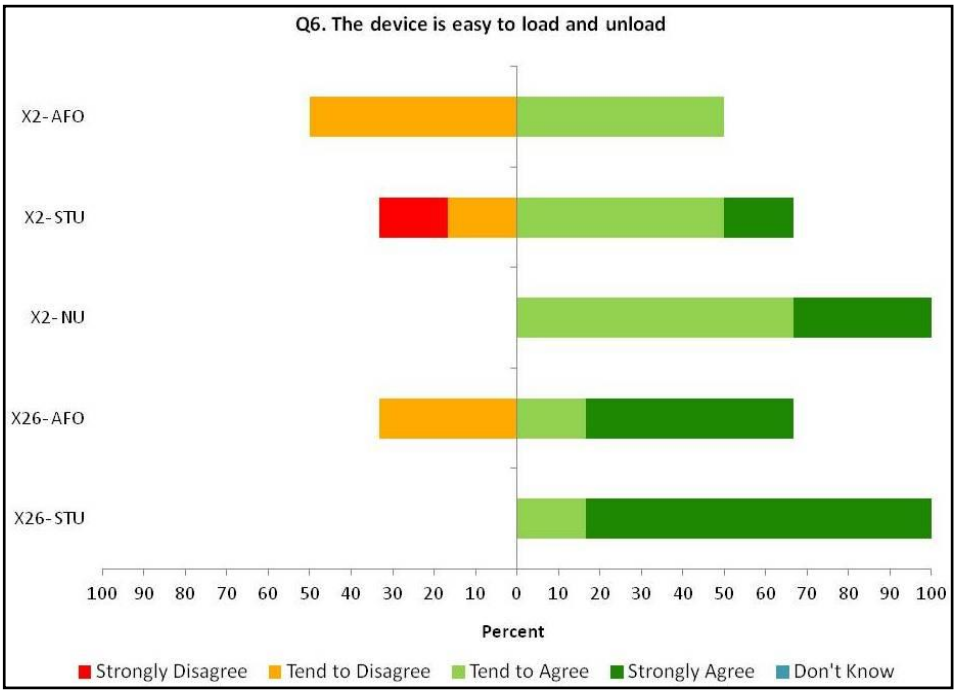
Q5. The device is easy to point and aim (CED-OR(TE)-06)



The officers from the three groups indicated they agreed or strongly agreed that the X2 was easy to point and aim, with the majority strongly agreeing. The STUs felt similarly about the X26 but 33% of the AFO disagreed.

Officers from the three groups commented that the **dual laser sight on the X2 increased the ability to effectively aim the device** and the X26 was the least accurate. One officer specifically stated that **although the X2 was larger and heavier it was easier to aim and more accurate.**

Q6. The device is easy to load and unload (CED-OR(TE)-06)

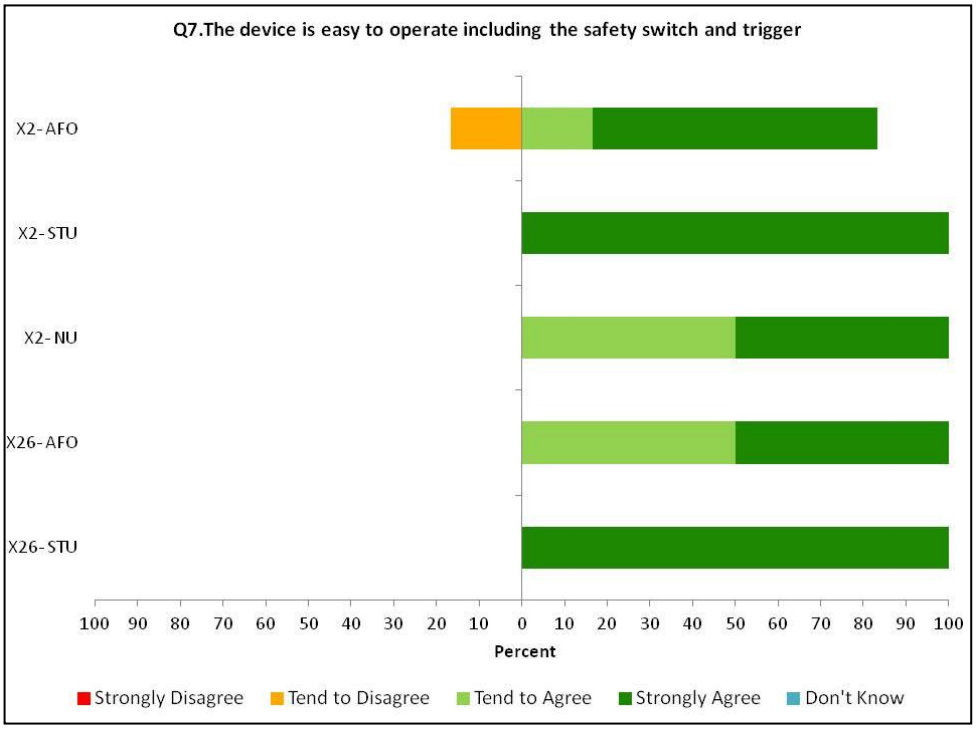


Half of the AFO group agreed with this question and half disagreed. Comments from the AFO and STU group reflected the responses that one officer found the X2 cartridge release button hard to master, one officer had slight difficulties with reloading during the exercises, and one officer found the X2 to be “so large, reloading was a cumbersome undertaking”. **Without prior experience of other CEDs, the responses indicate that the NU agreed or strongly agreed that the X2 was easy to load and unload**.

It was commented that having the two-shot capability on the X2 lessened the need to reload, but reloading was difficult under time pressure.

Unsurprisingly, having prior experience with the X26, the majority of AFOs and STUs agreed that the X26 was easy to load and unload, but the X2 was felt to be more accurate.

Q7.The device is easy to operate, including the safety switch and trigger (CED-OR(TE)-06)

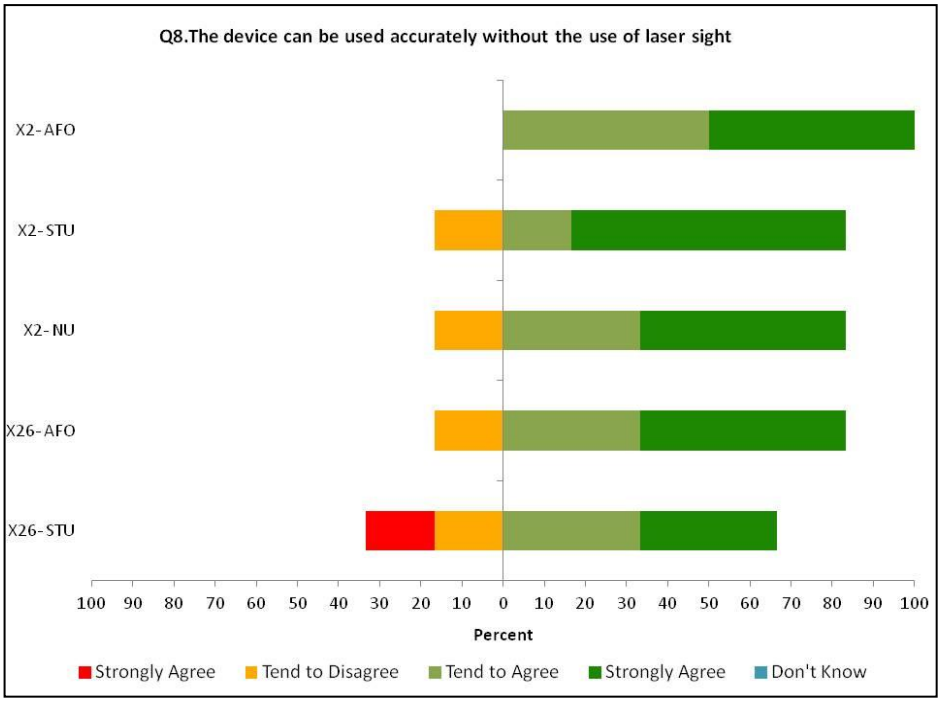


The majority of the AFOs strongly agreed that the X2 was easy to operate including the safety and trigger. One officer tended to disagree. There were a number of comments from officers in relation to the small size of the X2 grip. This may have attributed to the disagreeing officer’s response in conjunction with their familiarity with the operation of firearms and the X26. **100% of the STU officers strongly agreed that both the X2 and X26 were equally easy to operate.**

Officers commented on the ease of operation of the X2 including the arc button, even though only fundamental training had been provided prior to the handling trial.

Even with limited training, the NU group commented to say that the X2 was very easy to use, but one NU officer found the operation of the safety switch to be awkward. This could be addressed with further training and familiarisation.

Q8. The device can be used accurately without the use of laser sights (CED-OR(TE)-04)

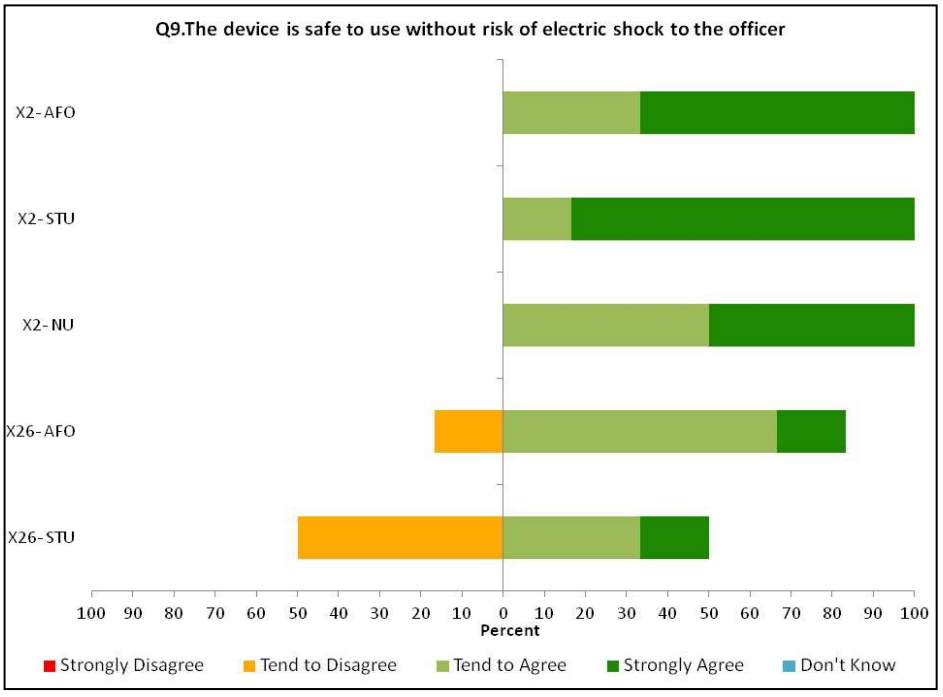


100% of the AFOs agreed or strongly agreed that the X2 can be used accurately without using the laser sights. One AFO commented to say that the fixed iron sights on the X2 were better than the X26.

The majority of the STUs and NUs agreed that the X2 can be used accurately without the laser sight, but one officer from each group tended to disagree.

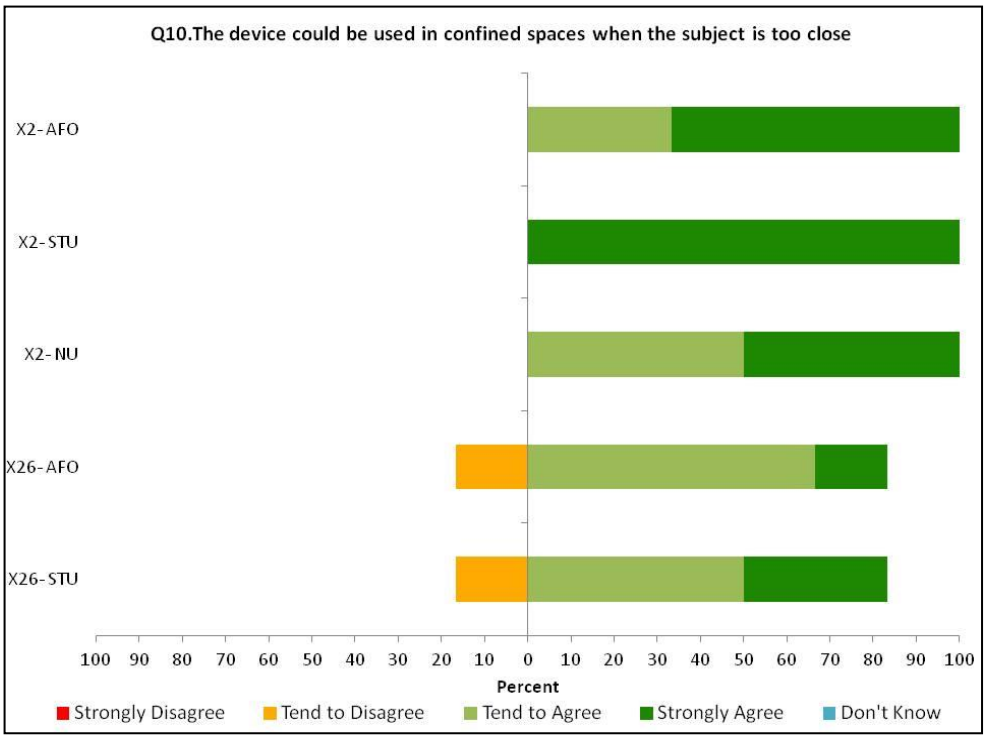
The general feedback for both CEDs and all groups was similar, except in the case of the X26 where 33% of the STU officers disagreed or strongly disagreed with this question.

Q9.The device is safe to use without risk of electric shock to the officer (CED-OR(TE)-02)



100% of the responses from the AFO, STU and NU groups agreed or strongly agreed that they felt most confident with the safety of the X2 device. This was not seen to be the case with the X26; although familiar with and trained to use the X26, some AFO and STU officers tended to disagree with this aspect. In the case of the STUs, 50% of the officers tended to disagree that the X26 was safe to use without the risk of electric shock.

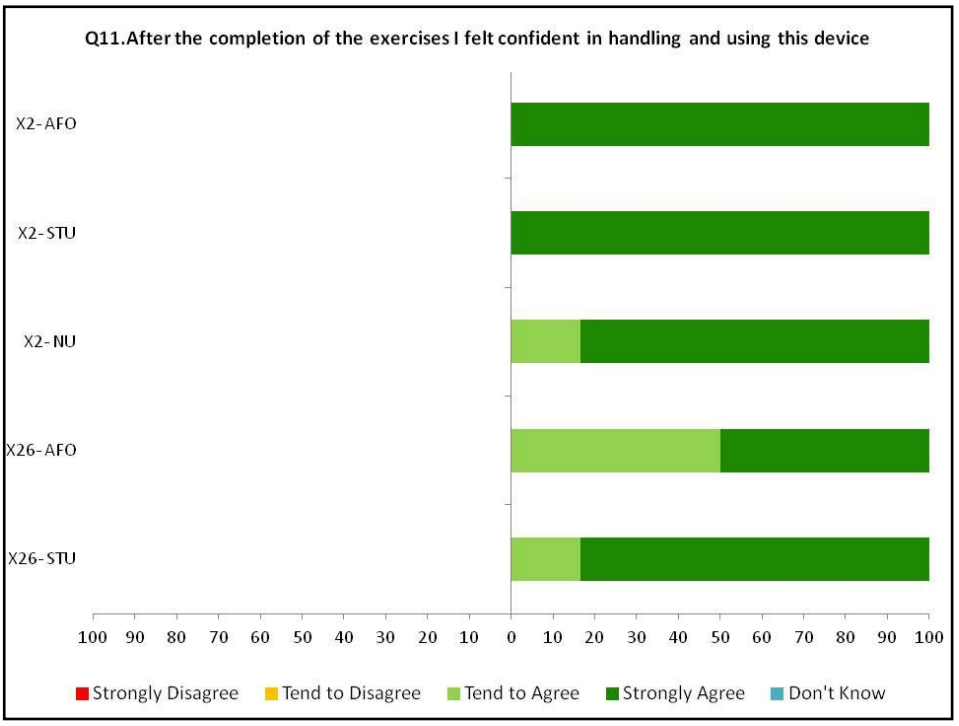
Q10. The device could be used in confined spaces when the subject is too close



The responses obtained from the AFO, STU and NU officer group indicated general agreement with the statement; **again indicating a higher level of performance of the X2 device**. The AFOs and STUs rated the X26 approximately the same, with two officers tending to disagree with the statement.

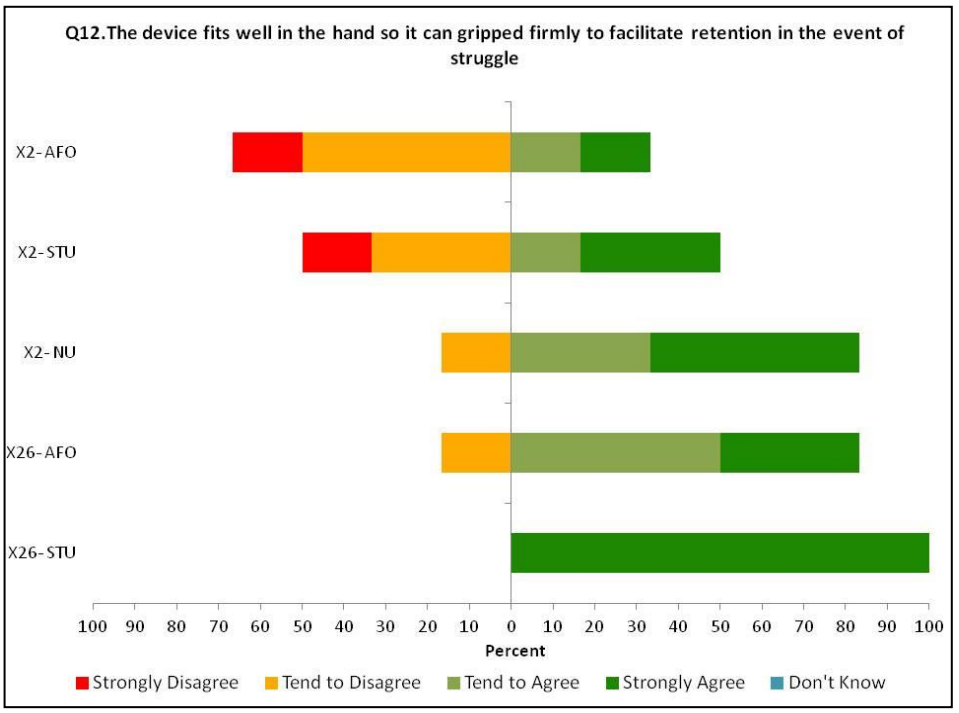
Comments from the AFOs and STUs indicated the awareness and recognition of the X2's capability to deliver barb spread and NMI by taking a second shot if required.

Q11. After completion of the exercises I felt confident in handling and using this device



All officers across all three groups were in agreement that following the exercises they felt confident using both Taser models. The **most confidence was seen with the use of the X2, with 100% of AFOs and STUs strongly agreeing with the statement.** Even with limited experience, 100% of the NUs felt they were confident in handling and using the X2. This was recorded in a comment from a NU that they would feel confident using the X2 out on the street.

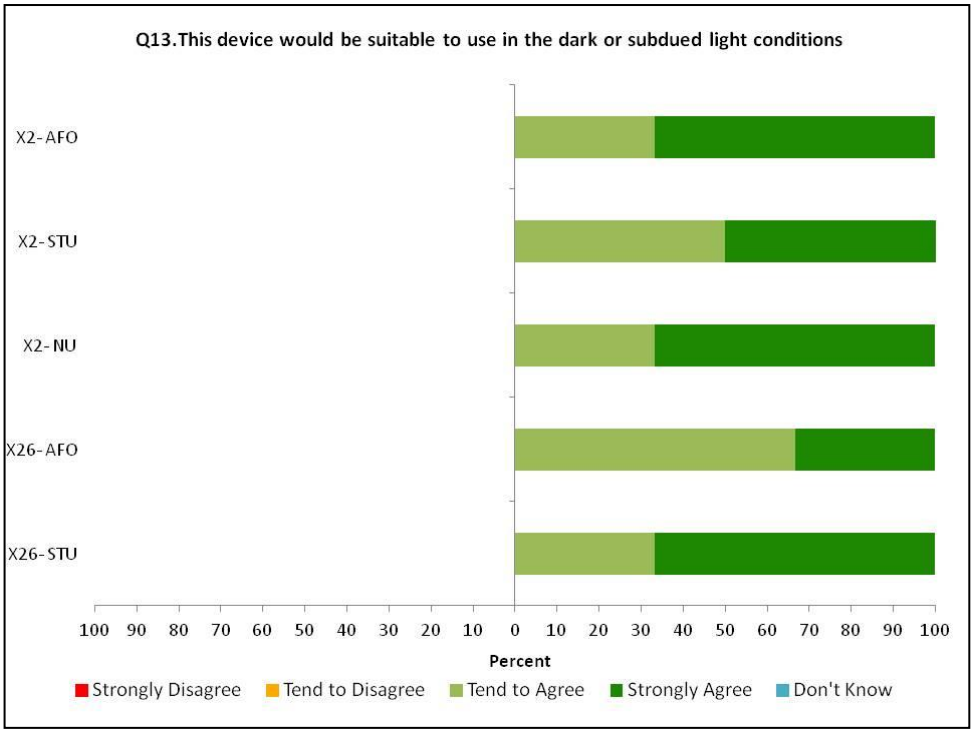
Q12. The device fits well in the hand so it can be gripped firmly to facilitate retention in the event of struggle



67% of the AFO group and 50% of the STU group disagreed with this statement, which was reflected in the users' comments that the grip size of the X2 is too small. Without having prior experience of the X26, the majority of the NU group agreed that the X2 had good handling.

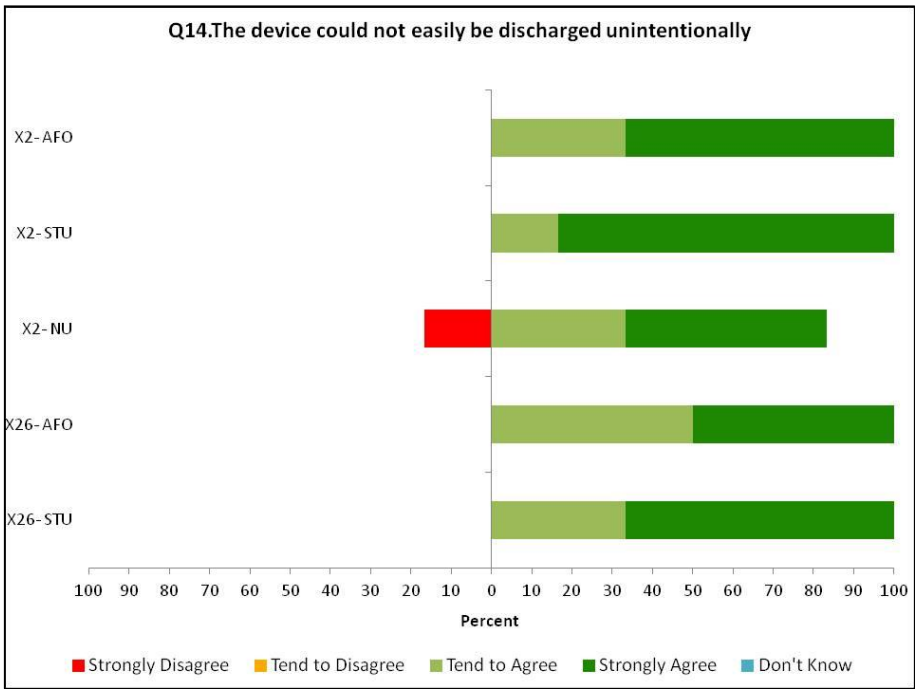
A large number of comments were received, across all three groups, highlighting that the X2's grip size was too small/short and could be an issue (noticeably from officers with smaller hands) and that **the grip size of the X26 was preferred to the X2.** However, one officer suggested that the benefit of the dual laser sights outweighs the small grip and any difficulties experienced with reloading.

Q13. This device would be suitable for use in the dark or subdued light conditions (CED-OR(TE)-03)



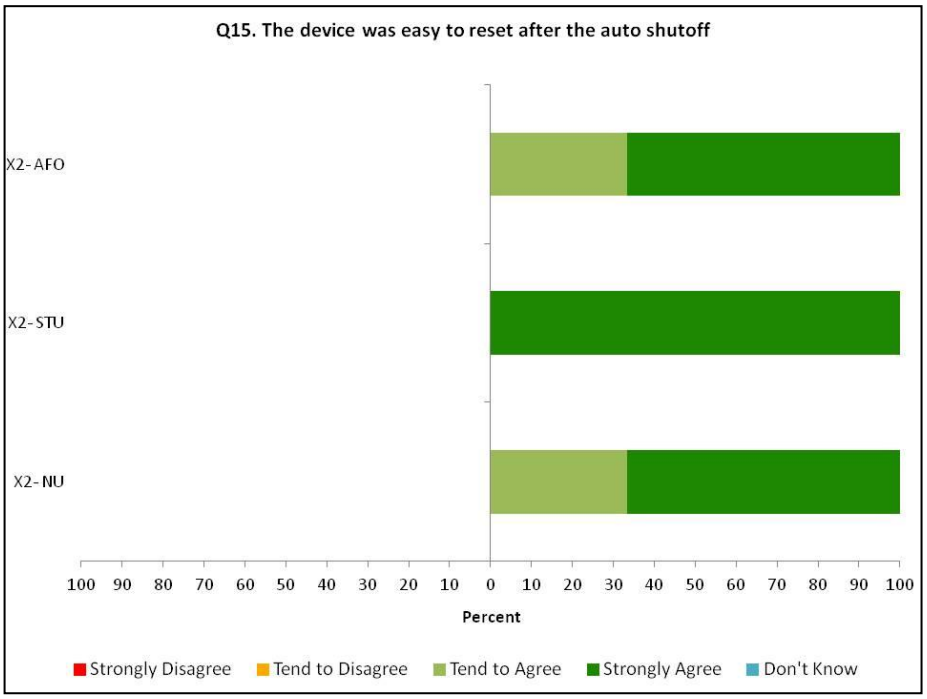
It was seen that all officers across all three groups agreed that the devices tested were effective in this scenario. AFO and NU officers indicated that 66% of each group strongly agreed that the X2 would be suitable to use in these conditions. Interestingly, the STU group thought the X26 was marginally better that the X26 in this aspect, whereas this view was reversed for the AFO group.

Q14.The device could not easily be discharged unintentionally (CED-OR(TE)-06)



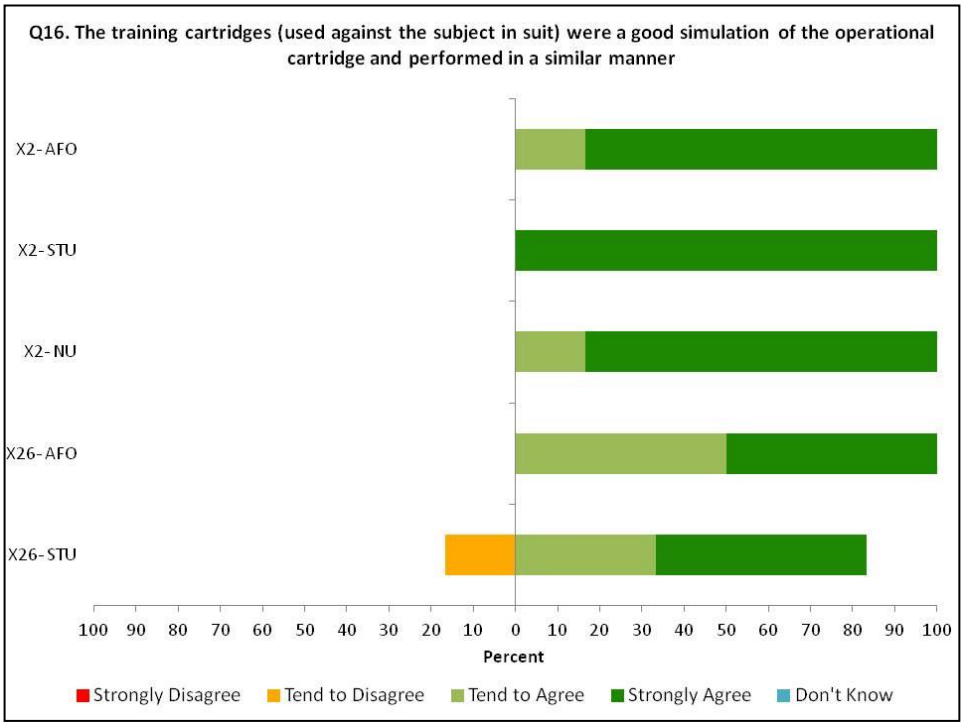
There was general agreement across all three groups that the devices performed well in this scenario. A slight difference between the groups was that a one NU officer indicated that they felt this was not the case for the X2 model. This could be attributed to the NU group of officers not being familiar with CEDs and only having experienced a fundamental level of training, which could be addressed.

Q15. The device was easy to reset after the auto-shut-off (CED-OR(TE)-11) (X2 only)



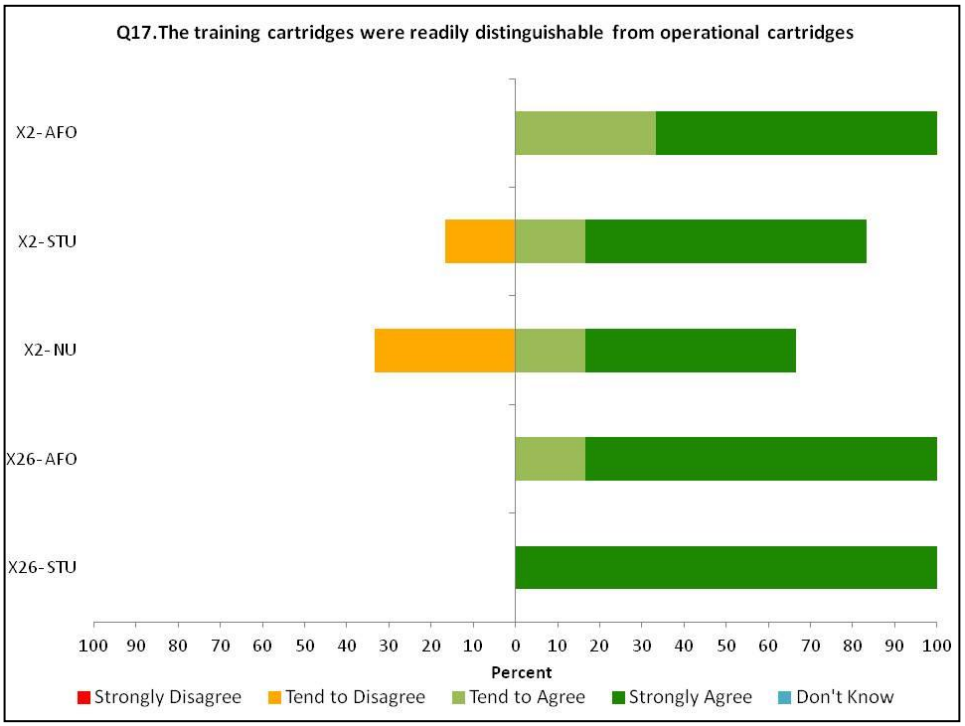
All three groups agreed that resetting the X2 after the cycle had automatically stopped due to the fitting of the APPM did not pose a problem. During this scenario exercise, no problems were observed and the users were able to reset and successfully re-energise the X2 against the target.

Q16. The training cartridges (used against the subject in suit) were a good simulation of the operational cartridge and performed in a similar manner (CED-OR(TE)-19)



100% of the officers from the three groups agreed that the X2 training cartridges were a good simulation of the operational cartridges. This view was equally split 50% by the AFOs with regards to the X26 cartridges, with a single disagreement recorded from an STU officer.

Q17. The training cartridges were readily distinguishable from operational cartridges (CED-OR(TE)-19)



There is a general agreement that the training cartridges for the X2 and X26 are readily distinguishable. The disagreement recorded with regards to the X2 is likely to be attributed to

the clear transit covers that are now fitted to the operational and training cartridges, as opposed to green colour for operational and blue for training that makes them more identifiable.

Only the Taser-trained (AFO and STU) groups answered the following two questions after using the X2 and X26 in the handling trial.

Q18. Overall which model did you prefer?

100% of the officers preferred the X2 over the X26. Primarily, because of the two-shot capability, dual lasers, and the ability to arc the X2 without removing the cartridges.

Q19. Overall which model did you like least?

100% of the officers responding liked the X26 the least. The users commented that they did not think there was a problem with the X26, only the X2 was better. The shortcomings of the X26 were felt to be only having a single shot before having to reload, reduced accuracy from a single laser dot sight, and the increased manipulation required to remove the cartridge in order to arc. However, the users did prefer the size of the grip of the X26 compared to the X2.

5. Faults during the testing

5.1 Introduction

During the course of the CAST assessment, nine Taser X2s were used and 895 X2 operational cartridges and 190 X2 training cartridges were fired; 435 X26 operational cartridges and 72 X26 training cartridges were also fired during the user handling trials. This chapter includes details of the cartridge faults that were identified.

5.2 Summary

All of the Taser X2s functioned correctly and no faults were recorded.

One X2 training cartridge and one X2 operational cartridge failed to fire on the first attempt (see Table 26). The fault with the cartridge was detected and recorded in the X2 event log as a FET fault (field effect transistor). TASER International is aware of the FET code, which is an error in reading the cartridge. After it was identified and raised by CAST in earlier tests, TASER International subsequently carried out corrective action by making modifications to the cartridge, but this result shows that the fault still exists, albeit in low numbers (one out of 895 operational and one out of 190 training). This information should be fed back to the manufacturer.

No faults were detected with the X26s or cartridges used in the handling trial, but one faulty XDPM was replaced. This reflects operational use where the X26 and the cartridges are generally found to be reliable.

Table 26: Details of cartridge faults detected during testing

Cartridge type	Fault	Cartridges affected (serial number)	Rectification
X2 25 ft training	Failed to fire during the accuracy and consistency test	No serial number on training cartridges	Fired successfully on the second attempt
Extract from data download showing cartridge fault detected:			
785	14 Mar 2016 16:25:03	Trigger	C1: FET Fault	2		85
X2 25 ft operational	Failed to fire during the handling trial	C6202AK1Y	Fired successfully on the second attempt
Extract from data download showing cartridge fault detected:			
267	06 Apr 2016 16:10:28	Trigger	C1: FET Fault	3		91
X2 25 ft training	Post firing knotted wire observed in two places	No serial number on training cartridges	

6. Electrical output test – DRDC

6.1 Introduction

In 2014, CAST partnered with DRDC to assess two new models of Taser, the Taser X26P and X2. DRDC undertook the work to characterise the electrical output of the X26P and X2. The electrical output specifications published in the TASER International X2 specification sheet dated 25/1/15 are the same as those in Table 27.

The work was to complete a study of the functional and electrical characteristics of 30 Taser X26P and 30 X2 models. In June 2014, a report was prepared by the Royal Military College of Canada for the DRDC and is included in the references[4].

6.2 Summary

The tests were conducted in accordance with the DRDC test procedure and the report states that:

- all of the Tasers passed the electrical tests;
- in all cases the Tasers produced electrical pulses that were well defined in amplitude and duration;
- no anomalies were noted during the tests;
- the pulse rates were found to be stable under laboratory conditions;
- the charge delivered was found to be within ±5% of the manufacturer's claim.

TASER International say that the specifications of the two models are identical and the waveforms should be identical with the exception of tolerance, load and environmental variations. The DRDC report identified small differences in the recorded waveforms between the X26P and X2. The report states that, on average, the duration of each pulse produced by the X26P was approximately 10% longer than that of the X2 which is still within TASER International's tolerances (Table 27).

Table 27: TASER International electrical output specifications

	Full waveform charge (µC)	Pulse duration (µsec)	Pulse rate (PPS)	Peak loaded amplitude (volts)
TASER International X26P and X2 factory test spec. range	63 ±9	50 – 125	19 ±1	840 – 1440

The DRDC report also highlighted a problem with cracking of the X2 cartridge after a test firing. No similar faults were observed during the CAST test, but any problems experienced with the cartridges are included in Section 5.

7. Overall conclusions

This report covers two main areas: firstly, assessing the X2 performance against the police operational requirements that were issued with the ITT, and, where applicable, to compare the characteristics of the Taser X2 against the Taser X26 that is currently in service with the UK police. To finalise the conclusions, a summary of the feedback comments from the officers who participated in the handling trial will be included.

7.1 Addressing the operational requirements

In assessing the Taser X2 against the operational requirements included in the ITT for a national procurement framework for a replacement CED, the results from the CAST tests and the user handling trial concludes that the X2 met the requirements.

7.2 Taser X2 performance and comparisons with the X26

Throughout the CAST testing and the user handling trial the X2 was found to be as follows.

- The X2 was found to be robust and reliable when subjected to repeated impacts from the drop tests, and when handled and operated by the police officers in a similar manner to that which would be encountered in training and operationally.
- The accuracy of the X2 cartridges showed an improved level of consistency over the X26 cartridges. The grouping of the X2 top barbs were closer around the POA than the X26 shots, resulting in a reduced mean radius at all test distances.
- The accuracy of the bottom barb was comparable to the accuracy of the top barb in relation to the POA indicated by the dual laser sights.
- The dual laser sights proved to be an accurate indication of shot placement. The difference between the barb spread indicated by the X2 dual laser sights and the actual mean barb spread from the shots fired was between only 2.0 cm and 3.8 cm difference across all the test firing distances.
- Overall results from the handling trial showed the X2 had a higher number of both barb hits (94%) over the X26 (91%).

- Comparing the maximum velocity from the Taser X2 SP top probes measured in the first 30 cm from the muzzle, they were found to be 10 m s^{-1} faster than the standard 21 ft X26 probes. The SP probes are 0.2 g lighter than the standard probes; however, the increase in velocity also increases the impact energy within this distance.

Probe type	Probe velocity (m s^{-1})			Probe mass (g)	Calculated energy (J)		
	min	av	max		min	av	max
SP (X2)	47.8	50.2	52.1	2.6	2.97	3.28	3.53
Std (X26)	39.1	41.1	42.0	2.8	2.14	2.36	2.47

- The range between the maximum and minimum velocity measurements for the SP probes was greater than the standard probes, being 4.3 m s^{-1} and 2.9 m s^{-1} respectively.

- In exercises where the participating officers were required to take two shots, all three groups were able to take the two shots with the X2 in less than half the time taken to fire and reload the X26.

- Several users commented to say that the grip of the X2 was too short or that they preferred the grip of the X26.

- Four officers felt the X2 was more difficult to reload or preferred reloading the X26.

- 100% of the Taser-trained officers preferred the X2 over the X26.

- The performance of the X2 batteries showed a marked improvement on that of the X26. The X2 APPMs are expected to deliver approximately 500 five-second cycles compared to the X26 XDPM, which is expected to deliver 195. During the user handling trial, the X2 APPMs indicated that they would last approximately twice as long as the X26 XDPM at a theoretical rate of 0.14% per activation (APPM) compared to 0.35% per activation (XDPM).

- The X2 cartridges are designed to be resistant to static discharge, which improves cartridge handling safety.

7.3 User feedback comments

Below is a summary of the positive and negative comments relating to the X2 provided by the users who participated in the user handling trial:

Positive aspects	Negative aspects
Two-shot capability	Handle too short
Using the X-Connect capability to take a second shot when the subject is too close	Because the X2 was heavier it was difficult to use with the weaker hand, especially for officers with smaller hands

Positive aspects	Negative aspects
Dual laser sights made the X2 more accurate	Cartridge eject button was difficult to operate
Improved fixed sight	
The arc button was in a good position to prevent accidental discharges or excessive use	
Ability to arc without removing cartridge	
Longer range cartridge	
More detailed display	

Overall, the general views were that users preferred the dual laser sights and second shot capability of the X2 and the confidence it gave in being accurate and providing a backup shot. These features were felt to outweigh the drawbacks of the X2's short grip not being as good as the X26 and the slight difficulties experienced with reloading the X2. These could be addressed through training and further familiarisation.

8. Further work and recommendations

8.1 Further work

SACMILL may recommend that the design of the new SP barb probe calls for additional experimentation to determine the differences, if any, in barb extraction force required, comparing the SP barb design with the current X26 cartridge barb ‘fish hook’ design.

8.2 Recommendations

The testing and evaluation described in this report covers a number of police requirements and can be used to predict how well the X2 can be expected to perform operationally by comparing its performance to the current operational weapon, the X26. However, certain new features of the X2, most notably the new waveform, cannot be directly compared to the X26 with regard to effectiveness and safety. Relative safety will be covered by referral to SACMILL, but effectiveness will necessarily be determined during operational use. This can be measured during a limited period of monitoring of operational use in a small number of forces. This period of monitoring can also be used to ensure the injury potential predicted by SACMILL is as expected, and is recommended by CAST to enable additional validation of data and predictions from this trial. A similar process was followed when the X26 replaced the M26.

As a result of the assessment and feedback from the users following the user handling trial, TASER International should consider the following suggestions:

- Cartridges that can be loaded either way up, like the X26, for when working at speed or in the dark.
- Make the X2 grip longer to aid handling.
- Fitting of a laser safety label that complies with IEC 60825-1.
- The cartridge FET fault has not been completely resolved.

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[6] Defence Scientific Advisory Council Sub-Committee on the Medical Implications of Less-Lethal Weapons (DOMILL). *Statement on the Medical Implications of Use of the Taser X26 and M26 Less-Lethal Systems on Children and Vulnerable Adults*. (Dstl/BSC/27/01/11 dated 4 April 2011 (amended 27 January 2012)). http://data.parliament.uk/DepositedPapers/Files/DEP2012-0729/96605%20Library%20Deposit.pdf

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[11] ACPO Taser Policy and Operational Guidance – Specially Trained Units – December 2008 Version 4. Taser Deployment Form in Appendix H.

[12] TASER International Version 19 Training and Information material. Released April 2013.

[13] Report from PHE on the Laser Measurement of Taser Devices, 8 January 2015.

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All the officers who volunteered to participate in the user handling trial.

<redacted> and <redacted> at PHE for conducting the tests on the laser sights.

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<redacted>. Also to <redacted> for conducting the EMC tests.

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APPENDIX A – Operational requirements

Table A1: Requirement table – CAST testing

Ref.	Mandatory requirement	Score criteria	X2 test results
CED-OR(TE)-06	Safety / Fire setting. Device has to have a setting which prevents accidental activation.	Pass/Fail	During the lab tests the safety switch on the CED was operated into the armed and safe position 290 times with no adverse or unexpected problems. The CED was also tested to verify that the CED will not fire when in safe mode. Score = Pass
CED-OR(TE)-08	The effect of the CED will be limited to an individual under normal usage. The accuracy and consistency shall be tested by CAST by firing 20 shots using the operational cartridges from the CED, secured in a fixed mount, aiming the top barb at a single point 1.4 m from the ground at following distances: 10 ft (3.0 m), 15 ft (4.6 m) and 20 ft (6.1 m). **Accuracy** The distance from the mean point of aim (MPA) to the mean point of impact of the top barb for 20 shots at the following	Scoring: **Accuracy** 10 ft – x direction +/- 3cm, y direction +/- 3cm 15 ft – x direction +/- 5cm, y direction +3cm -7cm 20 ft – x direction +/- 5cm, y direction +3cm -17cm Does not meet minimum	Operational cartridges **Accuracy** – mean point of impact (MPI) 10 ft = x -0.6 cm, y -0.7 cm 15 ft = x 0.3 cm, y -7 cm 20 ft = x 0.3 cm, y -16.5 cm Score = 75

<table>
<tr><th>Ref.</th><th>Mandatory requirement</th><th>Score criteria</th><th>X2 test results</th></tr>
<tr><td></td><td>distances (scored accordingly):

10 ft, 15 ft, 20 ft.</td><td>requirement = 0

Meets minimum requirement = 75

Exceeds minimum requirement by more than 50% in both directions = 100</td><td></td></tr>
<tr><td></td><td>Consistency

50% of shots when measuring the top barb must be within the mean radius of 20 shots (tolerance +10%) (scored accordingly).

The maximum radius of 20 shots will be determined at the following distances (scored accordingly):

10ft, 15ft, 20ft</td><td>Consistency

50% of 20 shots must be within the mean radius (tolerance +10%)

Does not meet minimum requirement = 0

Meets minimum requirement = 100</td><td>Consistency – percentage of shots within the mean radius

10 ft = 55%
15 ft = 70%
20 ft = 50%

Score = Pass</td></tr>
<tr><td></td><td>Maximum radius

Measuring from the top barb, the maximum radius is based on the maximum achievable accuracy and consistency in the UK. Any reduction in accuracy and consistency will be viewed unfavourably.</td><td>Maximum radius

The maximum radius of 20 shots:

<table><tr><td>10ft</td><td>15ft</td><td>20ft</td></tr><tr><td>0-5cm = 100</td><td>0-6cm = 100</td><td>0-9cm = 100</td></tr><tr><td>5-7cm = 75</td><td>6-9cm = 75</td><td>9-13 cm = 75</td></tr><tr><td>7-9cm = 50</td><td>9-12 cm = 50</td><td>13-17cm = 50</td></tr><tr><td>>9cm = 0</td><td>>12cm = 0</td><td>>17cm = 0</td></tr></table></td><td>Maximum radius

10 ft = 7.8 cm

Score = 50

15 ft = 8.1 cm

Score = 75

20 ft = 9.5 cm

Score = 75</td></tr>
</table>

Ref.	Mandatory requirement	Score criteria	X2 test results
	Training cartridges must perform comparably with the operational cartridges as tested above for accuracy and consistency. 10 training cartridges will be fired at 10 ft, 15 ft and 20 ft. **<u>Accuracy</u>** Comparing the results from the operational cartridges (as tested above), the distance from the MPA to the MPI of the top barb for ten shots using the training cartridges at the following distances must not exceed: 2 cm > the operational cartridges at 10 ft 4 cm > the operational cartridges at 15 ft 12 cm > the operational cartridges at 20 ft **<u>Consistency</u>** Comparing the results from the operational cartridges (as tested above), the mean radius of the top barb for ten shots using the training cartridges at the following distances must not exceed: 2 cm > the operational cartridges at 10 ft 4 cm > the operational cartridges at 15 ft 6 cm > the operational cartridges at 20 ft	**Training cartridges** Pass/Fail	**Training cartridges** **MPI:** 10 ft Ops = x -0.6 cm, y -0.7 cm Training = x -1.3 cm, y 0.8 cm Difference = within 2 cm 15 ft Ops = x 0.3 cm, y -7 cm Training = x -1.5 cm, y -6.1 cm Difference = within 4 cm 20 ft Ops = x 0.3 cm, y -16.5 cm Training = x -2.7 cm, y -12.1 cm Difference = within 12 cm **Mean Radius:** 10 ft Ops = 2.7 cm Training = 2.7 cm Difference = 0 cm 15 ft Ops = 3 cm Training = 3cm

Ref.	Mandatory requirement	Score criteria	X2 test results
			Difference = 0 cm 20 ft Ops = 5 cm Training = 8 cm Difference = 3 cm Score = Pass
CED-OR(TE)-09	The effective range of the CED will be commensurate with the maximum distance a subject could cover in an officer's reaction time. This varies from 0 to 21 ft. The range of the device will be tested to ensure that the range is at least 21 ft. 30 operational cartridges will be fired by the CED secured in a fixed mount at fixed person-sized target at a distance of 21 ft (6.4 m). The requirement is for both the top and bottom barbs to impact the target. 30 training cartridges will be fired by the CED secured in a fixed mount at fixed person-sized target at a distance of 21 ft (6.4 m). The requirement is for both the top and bottom barbs to impact the target.	**Operational cartridges** Pass/Fail **Training cartridges** Pass/Fail	All top and bottom barbs fired from the operational cartridges impacted the target at a range of 21 ft. Score = Pass All top and bottom barbs fired from the training cartridges impacted the target at a range of 21 ft. Score = Pass
CED-OR(TE)-12	Durability. The device needs to be robust enough to be used in situations of conflict management. Bidder to self-certify to a recognised standard. One device will be repeatedly dropped in the fully loaded condition from a height of 2 metres onto a steel plate in ten	Pass/Fail	The results from the drop test that followed the methodology concluded that there were no breakages or adverse problems, and that: The body of the X2 successfully survived the testing with no visual

Ref.	Mandatory requirement	Score criteria	X2 test results
	different orientations. The CED must be undamaged and function and operate correctly. (Please refer to Appendix B – CED drop test.)		damage other than some minor superficial scratches. After dropping the safety switch remained engaged (on position) and the CID display functioned correctly on both models and at no point did the X2 display any faults, function or discharge upon impact. After drop testing the X2, only one cartridge showed signs of damage (crack) but still fired successfully on the first attempt, as did all of the other cartridges (from both bays). The auto-shutdown and audio beep still functioned correctly for all of the drops on both models. Score = Pass
CED-OR(TE)-13	The CED will include a secure and auditable data recording system that will record the time, date and duration of each discharge and have the capability to log the event of the manipulation of the external safety within the device. This data has to be downloadable to a local computer. Each CED and operational cartridge must be permanently marked with a unique serial number. Such data recording should not rely on a separate unit or module. A compact form factor and continuity of evidence is required during post-incident investigation.	Pass/Fail	A successful data download was conducted at the beginning of the lab tests. A full data download was conducted at the end of the lab tests, which recorded that the Taser X2 was triggered 218 times, armed and disarmed 290 times. The data download logs the time, date and duration of each discharge and logs the manipulation of the external safety as an event as armed and safe within

Ref.	Mandatory requirement	Score criteria	X2 test results
	The minimum requirement is that the CED will accurately record the time, date and duration of each discharge and log the event of the manipulation of the external safety within the device without errors following completion of each CAST test.		the device. The data download recorded the two cartridge faults detected (as described in Section 5). The CED is marked with a unique serial number and 2D barcode. Each operational cartridge is marked with a unique serial number. A full data download was conducted on the completion of each test and no errors were detected in the data download. The data download was carried out using a bespoke download kit with USB lead. By inserting a simple plug-in interface into the battery port of the CED and connected to a computer using the data is automatically transferred to the Evidence Sync™ application. Score = Pass
CED-OR(TE)-15	The CED should be reliable in use and function as expected when activated in at least 99% of uses. Tested across the CAST tests and user handling trials. Measured as a percentage of cartridges that fail to fire or any other problems that result in failure to fire or the CED operating abnormally against the total number of firings	Pass/Fail	Through all of the lab tests the Taser X2 functioned as expected without any faults and all of the operational cartridges fired (895) successfully, except one that showed an initial fault but fired successfully on the second

Ref.	Mandatory requirement	Score criteria	X2 test results
	(excludes drop test). A statistical approach will be adopted to ensure a reliable measurement is obtained.		attempt. Score = Pass
CED-OR(TE)-19	Training cartridges shall provide comparable performance to a live operational cartridge. Training cartridges shall provide comparable accuracy and consistency to a live operational cartridge. A 5% failure rate for the functioning of the training cartridges is the minimum acceptable level.	Pass/Fail	The training cartridges performed comparably to the operational cartridges during the CAST lab tests meeting all of the requirements for accuracy and consistency. Out of 190 training cartridges fired during the CAST tests, one training cartridge showed an initial fault and failed to fire but successfully fired on the second attempt well within the 5% failure acceptable level. Score = Pass
CED-OR(TE)-20	Inert training model. The CED will also be available in an inert training version, where secondary functions such as laser sights, information displays, triggers and safety catches operate but no incapacitating or electrical effect is delivered. They should be readily distinguishable from operational devices (e.g. distinct colour and/or clear labelling). This cannot be subject to the requirements of the Firearms Act 1968. Assessment in CAST tests.	Pass/Fail	Two inert models serial numbers X1500008F and X15000091 were inspected by CAST from a technical perspective and the College of Policing from a training perspective. The results of the inspection concluded that both of the units were inert training versions, laser sights, information displays, triggers and safety catches operate but no incapacitating or electrical effect is delivered. The units were a distinguishable blue colour.

Ref.	Mandatory requirement	Score criteria	X2 test results
			X-ray images were taken of both devices (and compared with operational devices) to confirm that there were no high voltage components contained within the device. Score = Pass

Table A2: User handling trial

Ref.	Mandatory operational requirement
CED-OR(TE)-02	The CED shall not adversely affect the user during normal deployment.
CED-OR(TE)-03	The CED shall be able to be operated in all lighting conditions.
CED-OR(TE)-04	The CED shall have the ability to track and deploy against a target that is advancing and/or crossing at walking pace. The CED should have a clear targeting system, capable of targeting an individual subject and alerting them to its use.
CED-OR(TE)-05	The CED should be of a size and weight that is capable of being carried in a holster or carriage system commensurate with normal policing duties and equipment, including covert carriage.
CED-OR(TE)-06	The CED shall be capable of being operated by an individual officer using either hand. It should not rely on complex motor skills. Device has to have a setting which prevents accidental firing.
CED-OR(TE)-11	The CED shall allow the user to control the length of duration of the effect.
CED-OR(TE)-12	Durability. The device needs to be robust enough to be used in situations of law enforcement conflict management.
CED-OR(TE)-13	The CED will include a secure and auditable data recording system that will record the time, date and duration of each discharge and have the capability to log the event of the manipulation of the external safety within the device. This data cannot be edited and has to be downloadable to a local computer. The data must be associated to the unique ID/Serial no. of the device used.
CED-OR(TE)-15	The CED should be reliable in use and function as expected when activated in at least 99% of uses.

Ref.	Mandatory operational requirement
CED-OR(TE)-18	Training cartridges will also be available that can be used for scenario-based training in conjunction with operational CED and appropriate PPE. Training cartridges will not deliver the incapacitating effects or any other injury mechanism to the role-actor.
CED-OR(TE)-19	Training cartridges shall provide comparable performance to a live operational cartridge and shall be readily distinguishable from operational cartridges. (e.g. distinct colour, but not yellow or black).
CED-OR(TE)-20	Inert training model. The CED will also be available in an inert training version, where secondary functions such as laser sights, information displays, triggers and safety catches operate but no incapacitating effect is delivered. They should be readily distinguishable from operational devices (e.g. distinct colour and/or clear labelling). This cannot be subject to the requirements of the Firearms Act 1968.

Score = Passed all requirements

APPENDIX B – CED drop test

Method

This test was carried out to determine whether the X2 is likely to discharge when dropped and what kind of treatment it could withstand while still remaining in a working condition. The test was also designed to determine whether the Taser models could be adversely affected while appearing to be fully functional.

The test was designed to be deliberately extreme to give an indication of the problems that are likely to occur with the device if it is subjected to such harsh treatment.

The drop test involved dropping the loaded Taser from a height of 2 m onto a steel plate in ten different orientations and observing and recording any damage that occurred. This method was chosen as it is the technique used in the drop tests in CAST Standard for Police Chemical Irritant Sprays 23/14[7].

The Taser X2 under test was visually inspected and had new APPM batteries inserted, a function check and spark test was conducted and a data download carried out. To replicate operational carriage the Taser X2 was loaded with two cartridges, one on each cartridge bay.

With the safety switch in the on position the Taser was mounted in the drop test rig.

The CAST drop test rig held the Taser in the positions shown in Figure B1 so as to present each planar surface and the four vertical corners of the unit to the impact. The drop rig mechanism was released and the Taser was allowed to free fall into the steel plate.

Drop position	Impact point
1	Bottom
2	Front
3	Top
4	Back
5	Right-hand side
6	Left-hand side
7	Front bottom corner
8	Top back corner
9	Back bottom corner
10	Front top corner

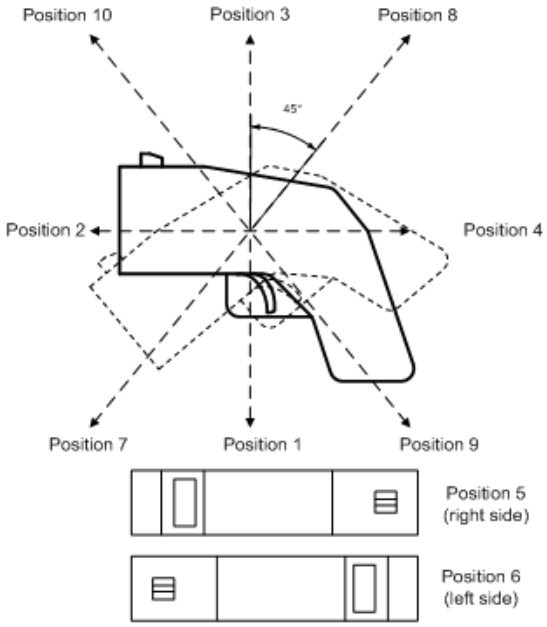


Figure B1: Shows the X2 in drop positions 1, 2 and 3 (left to right)

After each drop a visual inspection of the Taser X2 and the cartridges was conducted. The Taser was armed and the CID display checked. If it was deemed safe to do so both bays of the Taser X2 were fired and activated for a full five-second cycle. The CID was checked again and verification made that the APPM sounder was audible. This was repeated for all ten drop positions and at the end of the test a data download was completed.

Results

After each drop there was no significant visual damage to the Taser X2 so the same Taser was used for all ten drops. After ten drops only minor superficial scratches could be seen and the safety remained engaged and the CID display showed no faults or signs of damage. The data download was complete for both models and showed the health to be GOOD.

The X2 cartridges proved to be robust. After dropping from all ten positions no damage was observed except from position 2 which resulted in a minor crack in the cartridge as shown in Figure B2 but is still fired successfully. All of the cartridges tested fired successfully from both bays on the first attempt.

Figure B2: Damage to the X2 cartridge when dropped from position 2

APPENDIX C – Details of the accuracy tests

Method

The X2 was clamped in the mounting rig fixed to a tripod and was checked with an inclinometer to ensure it was level and upright to within ±0.2°. The height of the tripod was set so that the position of the top barb was 1.4 metres from the ground. A flat cardboard target was secured at the set test range from the front of the Taser cartridge and marked with cross hairs at a height of 1.4 metres from the ground. The centre of the cross hairs was designated the POA and the origin (co-ordinate 0,0 position) from where the measurements were taken. The Taser's laser sight was turned on and the top laser was aligned with the cross hairs, and if necessary, fine adjustments were made. For every shot the top laser was sighted at 0,0. For the purposes of repeatable testing a consistent POA was identified to be the centre of the chest and slightly above the nipple line (co-ordinate 0,0). This is not the operational POA.

With both bays loaded the X2 laser sight was turned and the position of the bottom (flashing) laser was also marked as a datum.

After each shot the impact location of the top and bottom barb were recorded as x and y coordinates. The measurement from the laser dot POA to the impact point for the top and bottom barbs was taken and the distance between the top and bottom barbs (barb spread) was also recorded. Tests were conducted firing from the left- and right-hand bay of the X2 and 25 ft firing operational and training cartridges.

Accuracy tests for the Taser X26 were conducted by CAST in 2015 following the same methodology and firing the standard 21 ft operational cartridges. The Taser X2 cartridges are a different design with a range of 25 ft and fire the longer SP barbs.

The accuracy data from the X26 and X2 cartridges will be compared.

Results

Figures C1 to C4 show the results of the accuracy tests for the different models of Taser and cartridges. The figures show the hit location of the top and bottom barbs at each distance as they would fit on a man-sized target with the outline showing the torso, leg and arm areas. The results show the relationship between the POA (0,0) where the top laser is sighted, and the hit location of the top barb which is represented by a red diamond. The hit location of the bottom barb is represented by a blue square. The position of the bottom laser for the X2 is represented by a light-blue triangle.

The manufacturer states that the X2 laser sights are zeroed during assembly so that the lasers coincide with the top and bottom probe at a distance of 4.6 m (15 ft) although the test results observed an optimum accuracy at 10 ft (3.0 m).

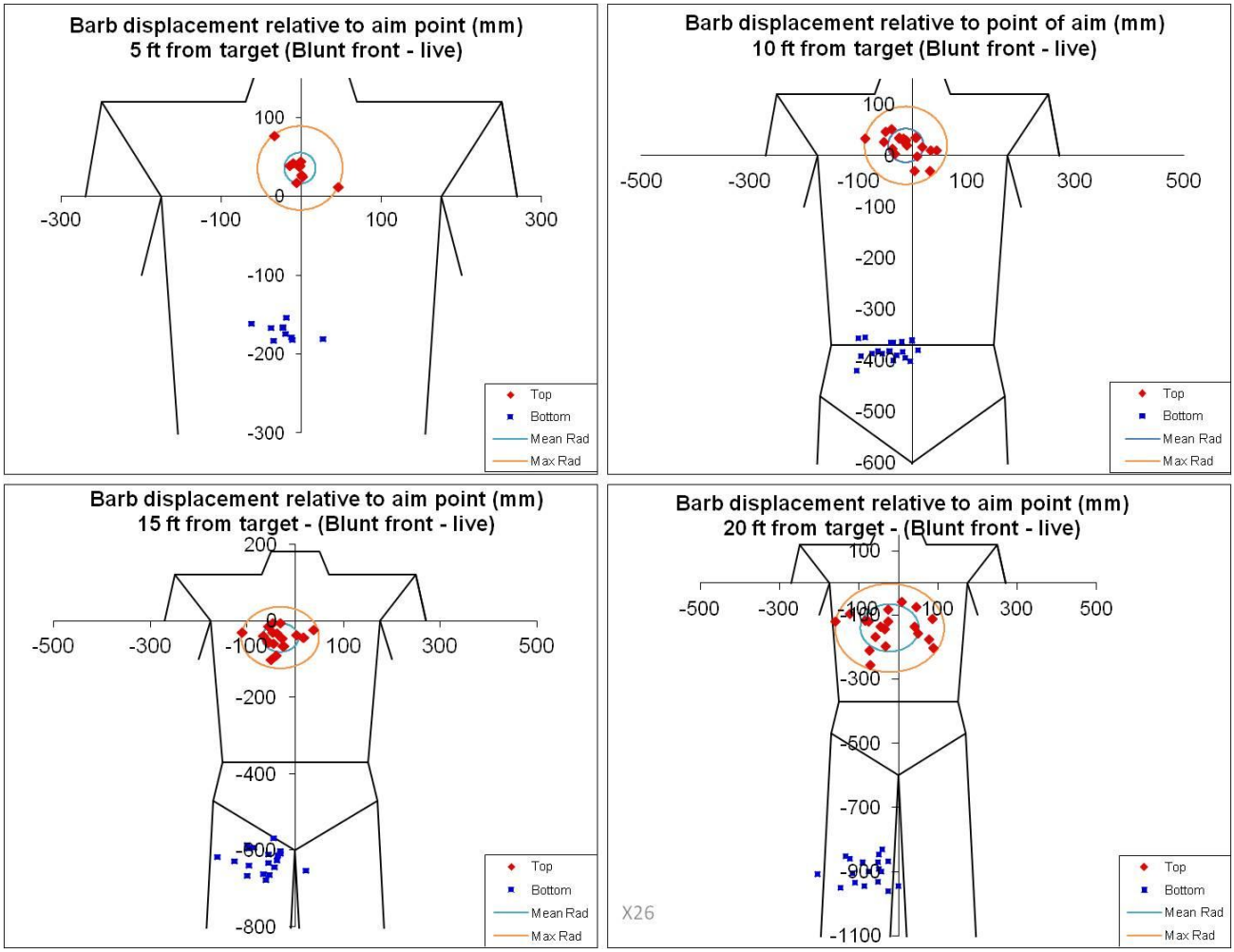
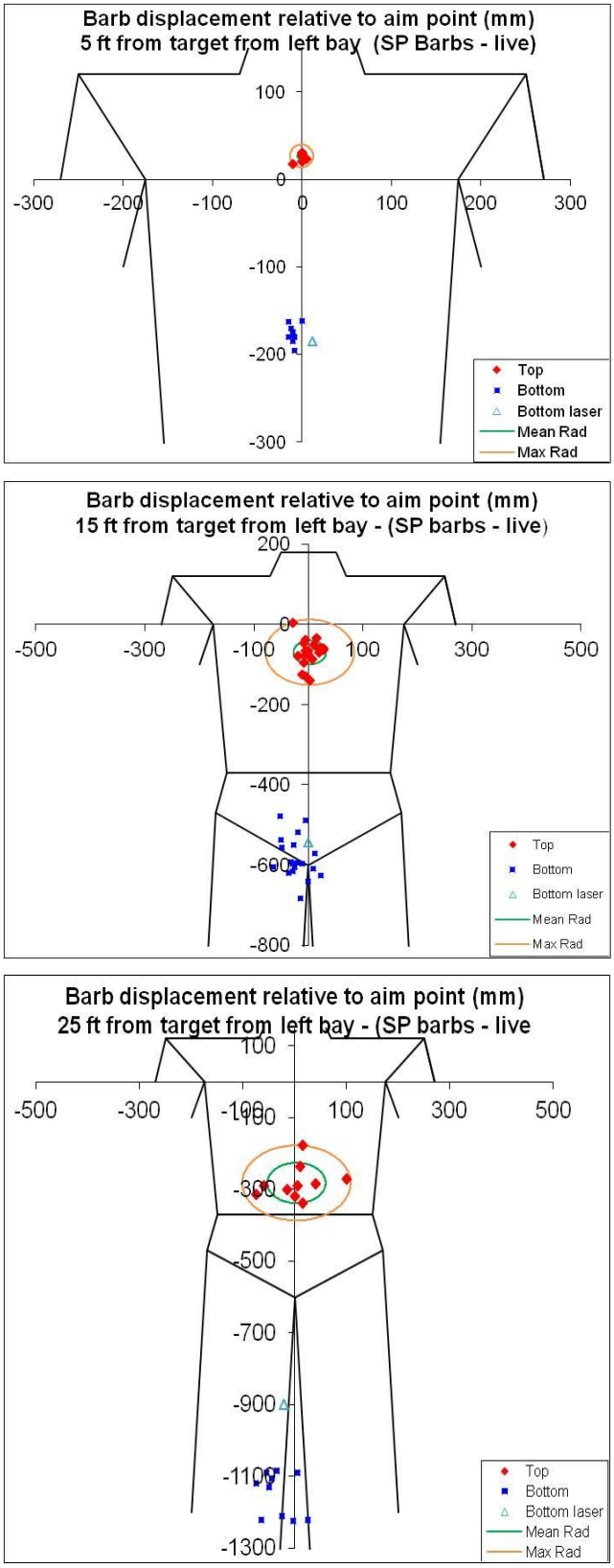
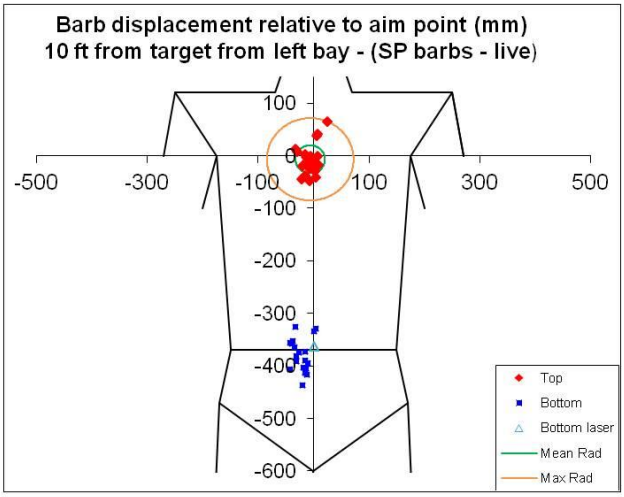


Figure C1: Position of standard operational cartridge barbs when fired from the X26 at 5 ft (1.5 m), 10 ft (3.0 m), 15 ft (4.6 m) and 20 ft (6.1 m)

Figure C1 shows the results for the Taser X26 accuracy tests when firing the 21 ft standard operational cartridge during CAST tests in 2015 at 5 ft (1.5 m), 10 ft (3.0 m), 15 ft (4.6 m) and 20 ft (6.1 m).

It can be seen that the top barb impacts above the POA at 5 ft (1.5 m) and 10 ft. At 10 ft, 15 ft and 20 ft there is spread of the barbs in a more horizontal plane, dispersing more widely as the firing range increases. This is also reflected in the spread of bottom barbs.





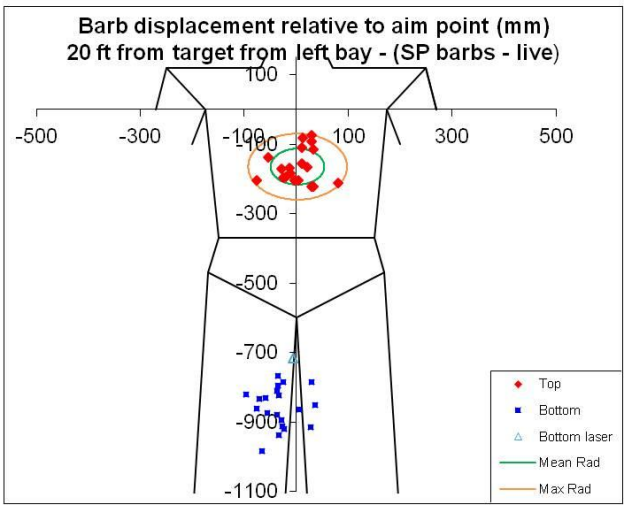


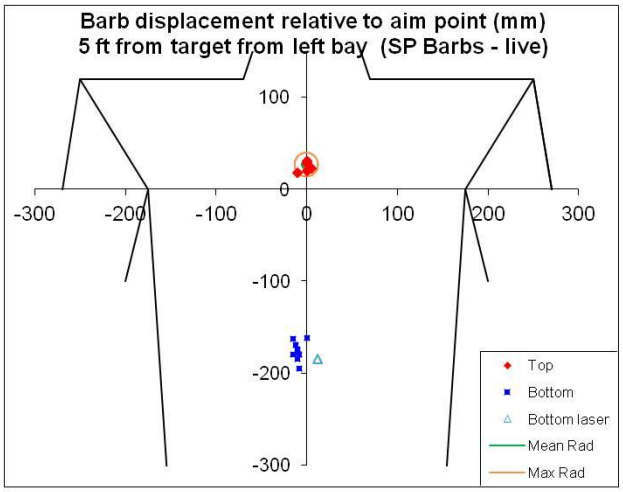
Figure C2: Position of standard operational cartridge barbs when fired from the X2 (left bay) at 5 ft (1.5 m), 10 ft (3.0 m), 15 ft (4.6 m) and 20 ft (6.1 m) and 25 ft (7.6 m)

Figure C2 shows the results of the accuracy testing of the Taser X2 25 ft operational cartridges using the left bay only and fired at distances of 5 ft (1.5 m), 10 ft (3.0 m), 15 ft (4.6 m), 20 ft (6.1 m) and 25 ft (7.6 m) from the target. At 5 ft, 10 ft and 15 ft the shots are closely grouped around the POA with a small number of outliers. The manufacturer states that the top and

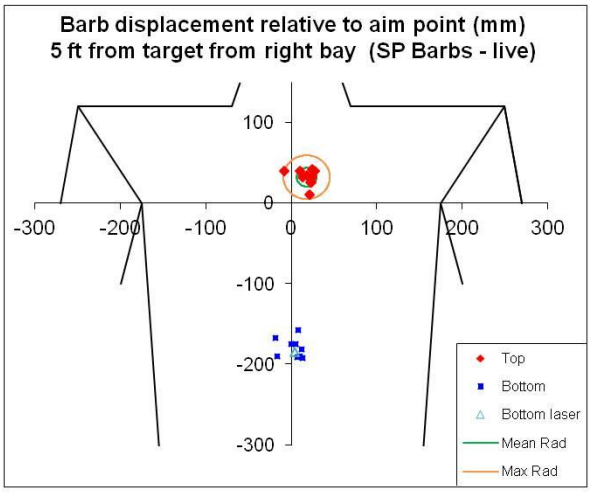
bottom laser sights are zeroed to indicate the approximate POI of the barbs at 15 ft; however the results from this test suggest that better accuracy was observed at 10 ft. The observations from the tests reflect this with a very minor MPI to POA top barb drop of just 7.0 cm. At 20 ft and 25 ft the top barb continues to drop from the POA and shot spread increases with the bottom barb. Compared to the X26 an improved level of consistency of the top barb grouping from the X2 was observed.

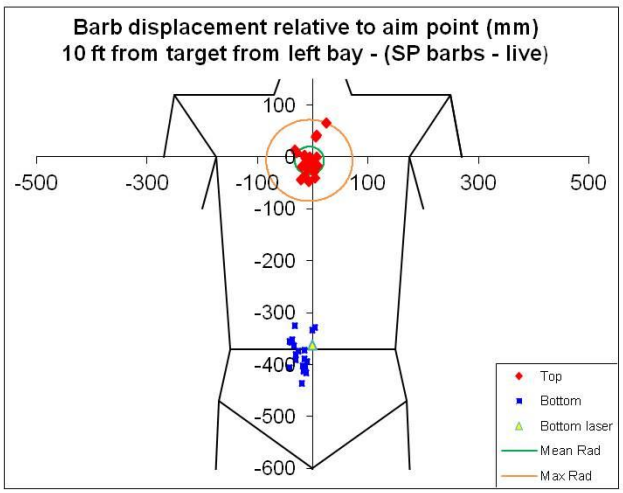
The results comparing the accuracy between the left and the right bay are shown in Figure C3. Overall the level of consistency between the bays is similar. In the cases where the maximum radius is seen to increase at is attributable to one or two outliers as can be seen at 10 ft. Comparing with the left bay the MPI of impact of the right bay was observed to move to the right between 18 and 35mm between 5 ft and 20 ft.

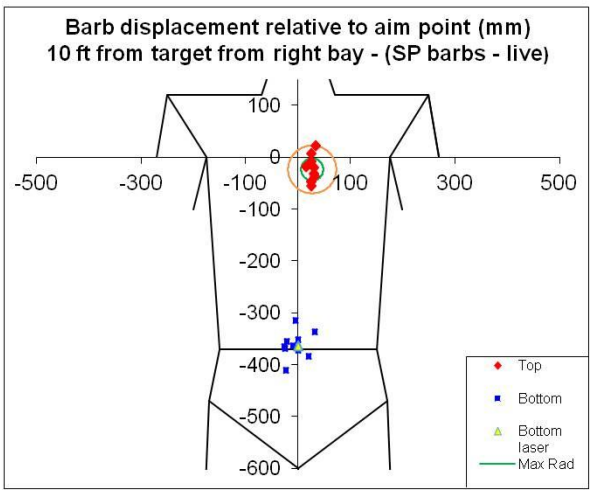
Left-hand bay (operational)



Right-hand bay (operational)







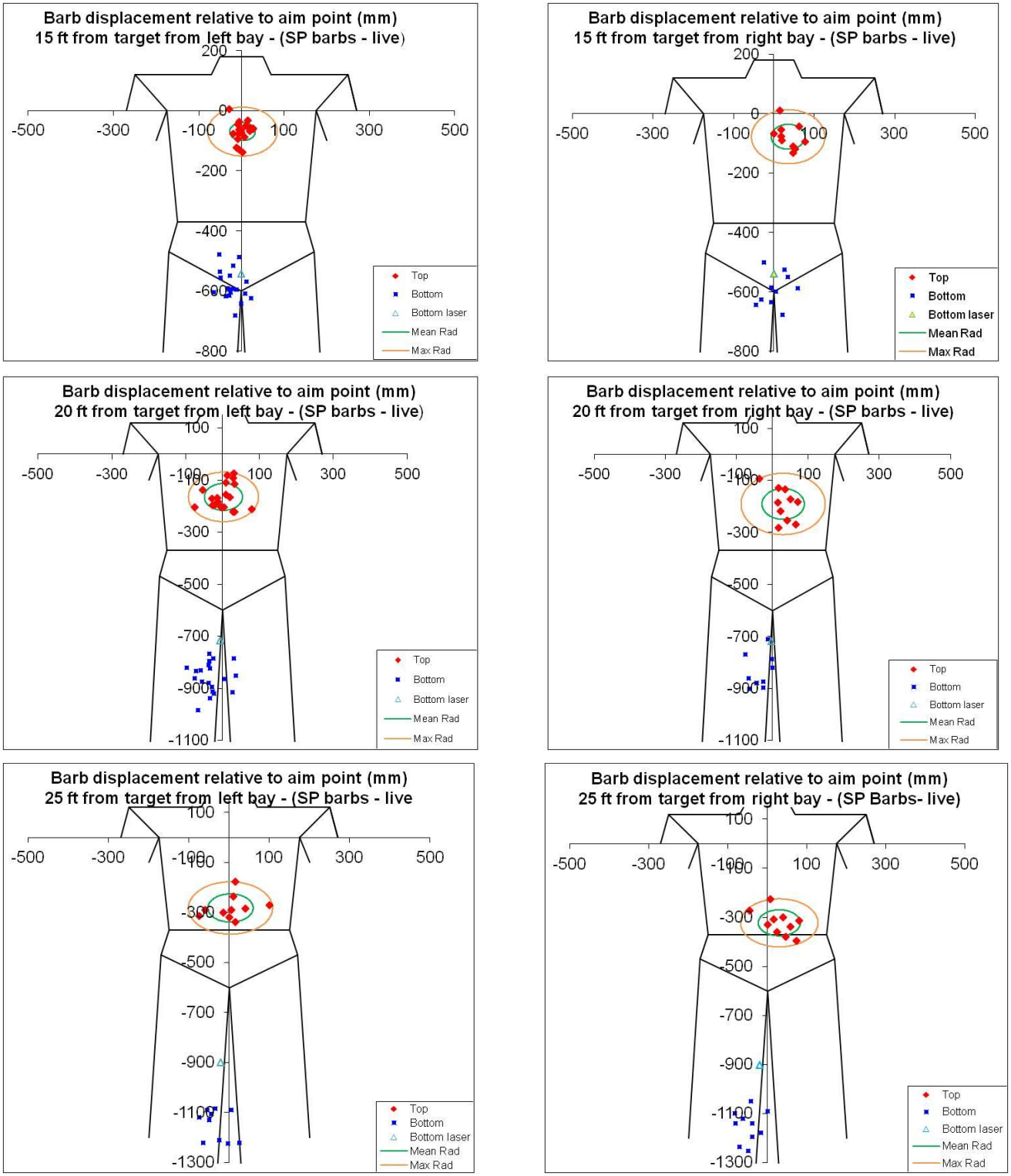
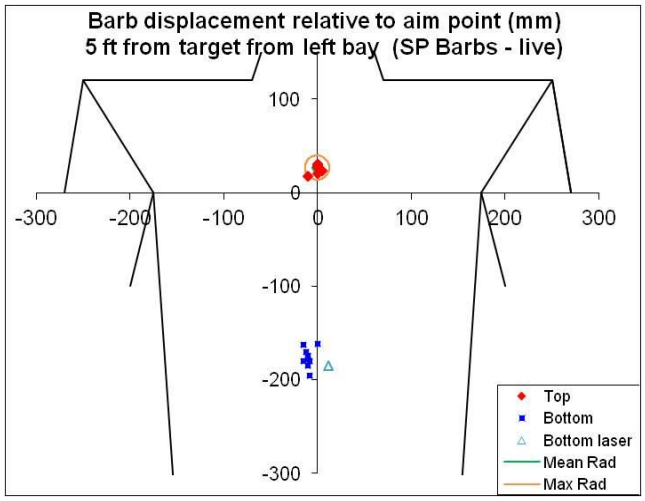
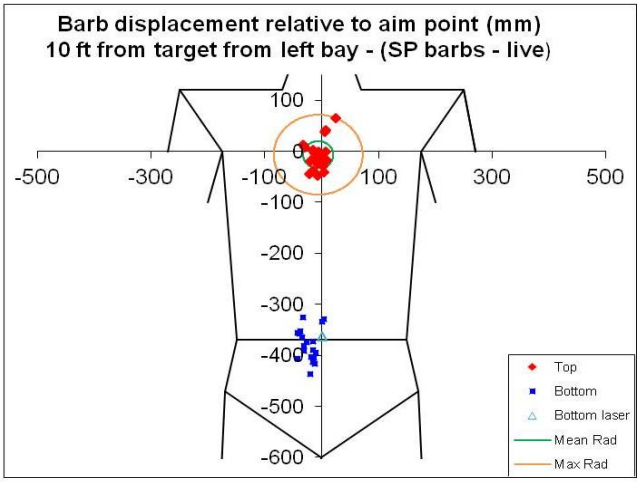


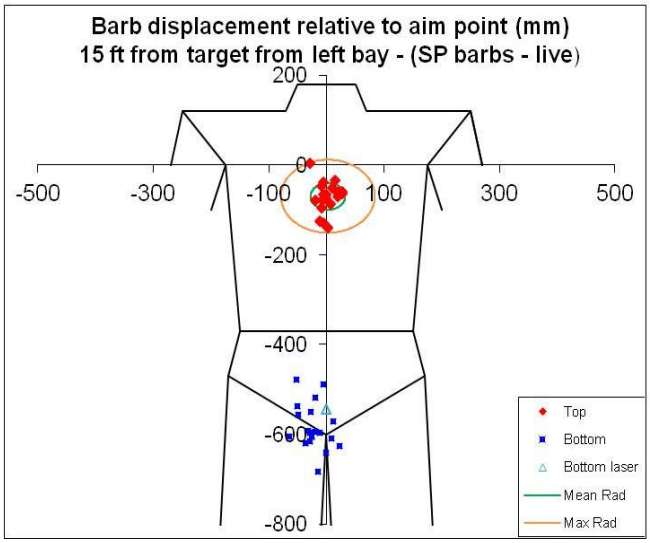
Figure C3: Position of standard operational cartridge barbs when fired from the X2 left bay and right bay at 5 ft (1.5 m), 10 ft (3.0 m), 15 ft (4.6 m) and 20 ft (6.1 m) and 25 ft (7.6 m)

Figure C4 below shows the results of the accuracy tests of the operational and training cartridges fired from the left bay of the Taser X2 at 5 ft (1.5 m), 10 ft (3.0 m), 15 ft (4.6 m), 20 ft (6.1 m) and 25 ft (7.6 m). At 5 ft, 10 ft and 15 ft the MPI and the barb spread can be seen to be comparable for the two different types of cartridges. At 20 ft the spread of the top barb shots significantly increases with the maximum radius of the operational cartridges being 9.5 cm compared to 16.7 cm for the training cartridges at this range. Overall the cartridge types are of comparable performance with the POI remaining relatively central to the POA.

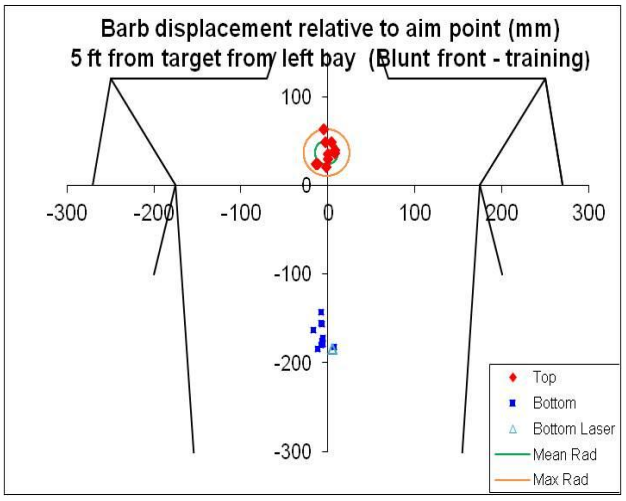
X2 operational (left bay)

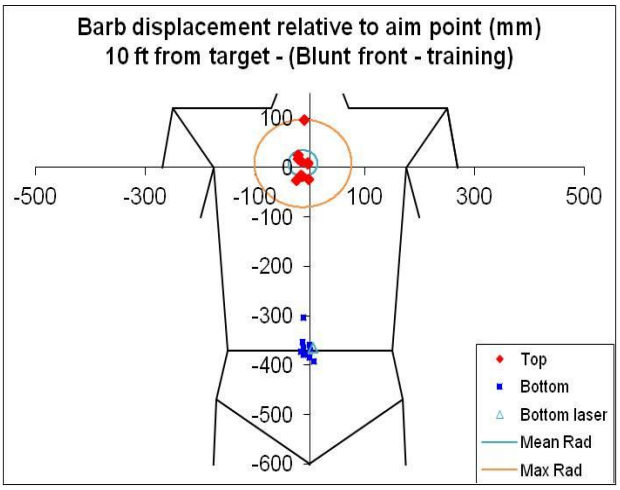


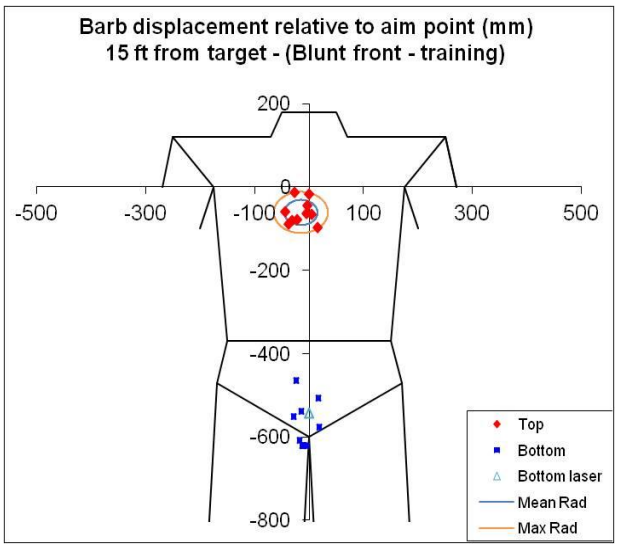


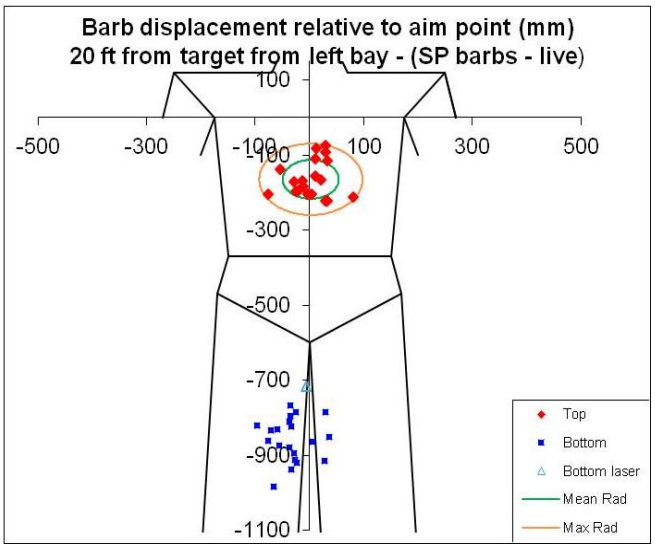


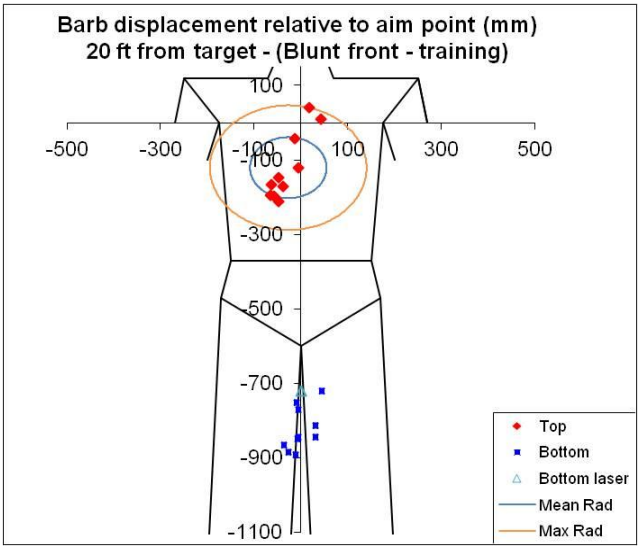
X2 training (left bay)

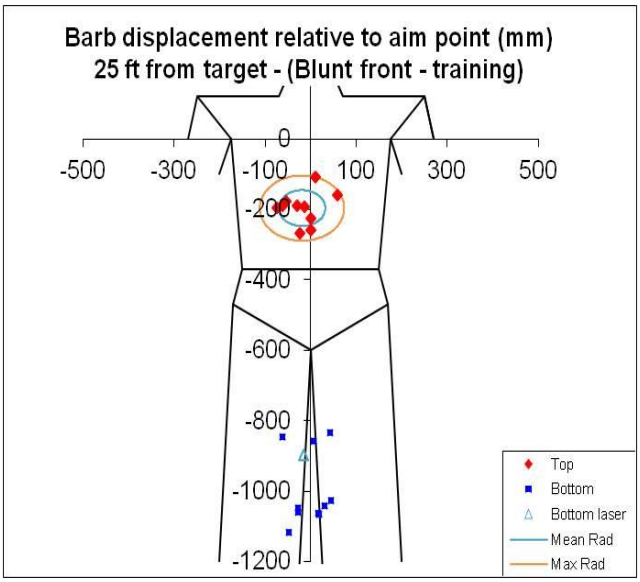












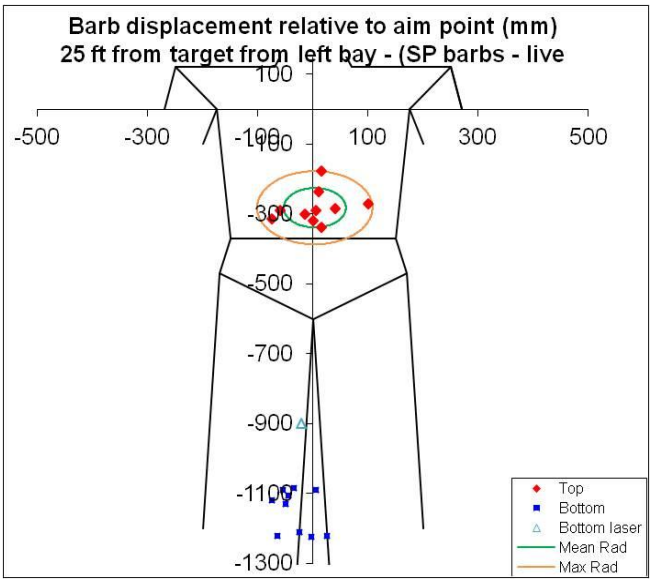


Figure C4: Position of standard 25 ft operational and training cartridge barbs when fired from the X2 at 5 ft (1.5 m), 10 ft (3.0 m), 15 ft (4.6 m), 20 ft (6.1 m)

APPENDIX D – Details from the user handling trial

Appendix D includes the results of each Taser model for each scenario exercise as summarised in Section 4.5.

The results are displayed as graphs to compare the devices. The results for AFO and STU participant groups are amalgamated as Taser-experienced users and can be compared with the NU group who had no previous Taser experience.

The graphs show the number of shots where both barbs hit the target, where only one barb hit the target and when both barbs miss the target. Where one barb hit the target it is to be taken that one barb missed the target. Where both barbs hit the target the point on the target (body, head, neck and groin) is indicated. The table at the top of each graph shows the percentage of successful shots when both barbs hit the target.

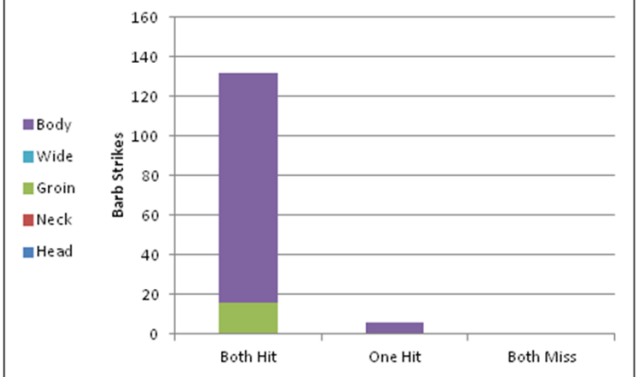
Exercise 1: Standard upright

Purpose: The aim of this exercise was to determine the accuracy and handling characteristics of each Taser when fired under ideal conditions (standing, static target, face on) taking two shots. Taking two shots compares the second shot capability of the X2 with that of the X26 that requires reloading before taking the second shot.

Action: The Taser was loaded and in the ready position. On command the officer raised the Taser and fired at the target from a distance of 4 m (13 ft) using the laser sights. The officer was instructed to do this as quickly as possible. The exercise was repeated three times for each model of Taser.

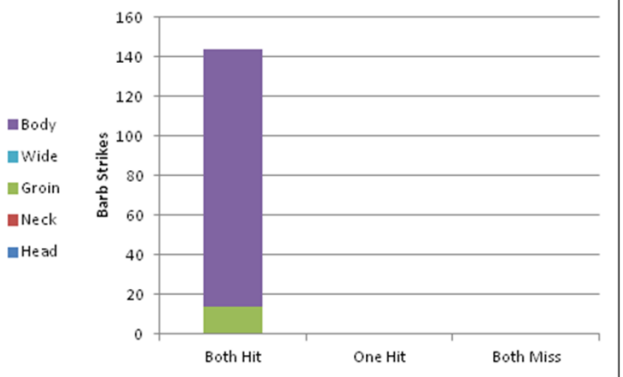
Results: Twelve Taser-trained officers each fired six shots with the Taser X26 and six shots with the X2. Six non-Taser-trained officers fired six shots with the X2.

Both hit- 92%	Exercise 1- AFO + STU		X26
No. of shots	66	6	0



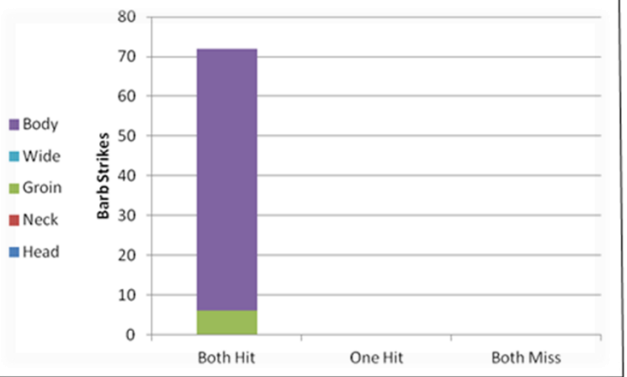
No. of Bounces: 0

Both hit- 100%	Exercise 1- AFO + STU		X2
No. of shots	72	0	0



No. of Bounces: 0

Both hit- 100%	Exercise 1- NU		X2
No. of shots	36	0	0



No. of Bounces: 0

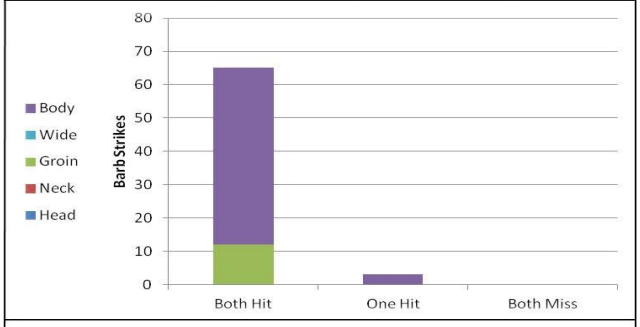
Exercise 2: Defensive position

Purpose: The aim of this exercise was to determine if the accuracy and handling characteristics of each Taser was affected when the officer fired starting from a defensive position on the floor and rising to a standing position while the Taser was still cycling.

Action: The Taser was loaded and in the ready position. On command, the officer raised the Taser and fired at the stationary target from a distance of 4 m (13 ft) using the laser sights and rose to a standing position. The officer was instructed to do this as quickly as possible. The exercise was repeated three times for each model of Taser.

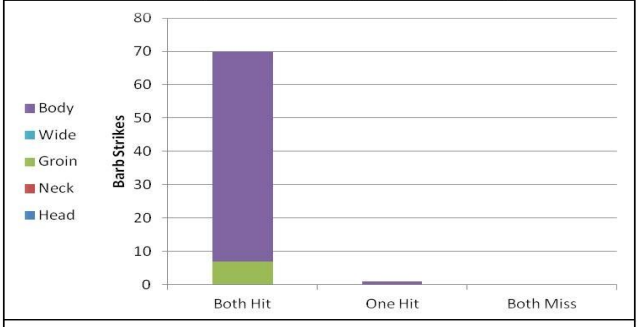
Results: Twelve Taser-trained officers each fired three shots with each model of Taser. Six non-Taser-trained officers fired three shots with the X2.

Both hit- 92%	Exercise 2- AFO + STU		X26
No. of shots	33	3	0



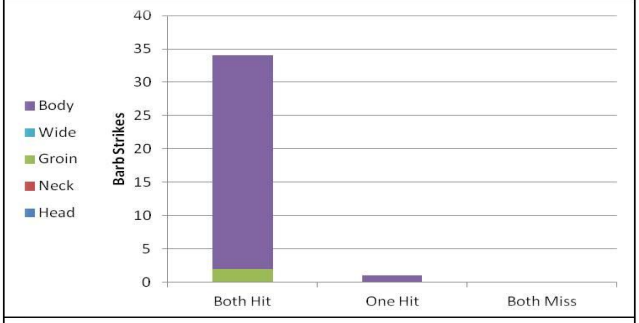
No. of Bounces: 0

Both hit- 97%	Exercise 2- AFO + STU		X2
No. of shots	35	1	0



No. of Bounces: 0

Both hit- 94%	Exercise 2- NU		X2
No. of shots	17	1	0



No. of Bounces: 0

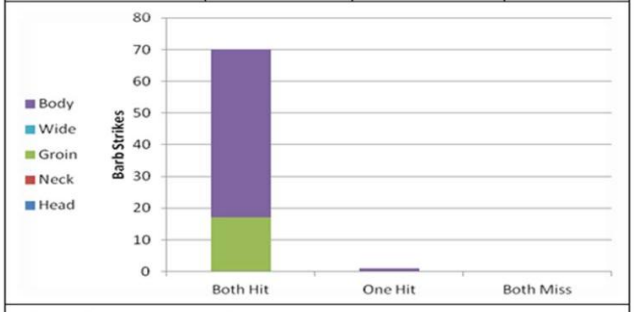
Exercise 3: Low light

Purpose: The aim of this exercise was to determine the accuracy and handling characteristics of each Taser when fired under low-light conditions using the LED flashlight and laser sights.

Action: This exercise was carried out in low-light conditions. The Taser was loaded and in the ready position. On command, the officer raised the Taser and fired at the stationary target from a distance of 4 m (13 ft) using the laser sights. The officer was instructed to do this as quickly as possible. The exercise was repeated three times for each model of Taser.

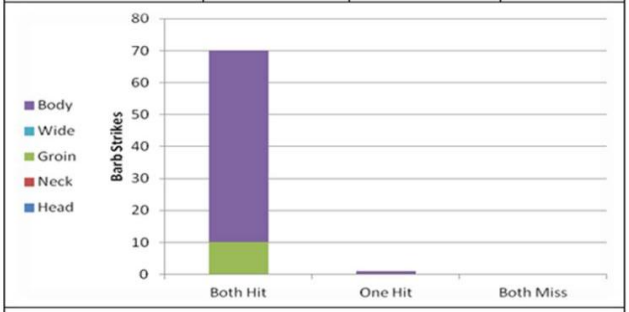
Results: Twelve Taser-trained officers each fired three shots with each model of Taser. Six non-Taser-trained officers fired three shots with the X2.

Both hit- 97%	Exercise 3- AFO + STU	X26
No. of shots	35	1	0



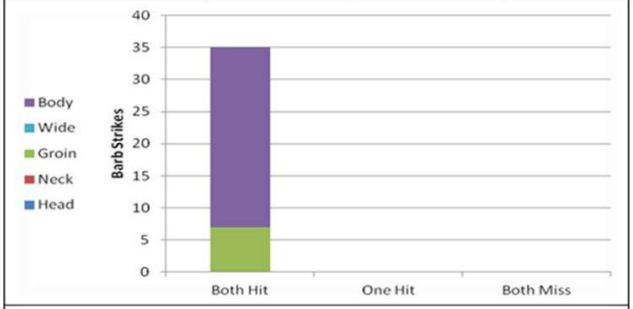
No. of Bounces: 0

Both hit- 97%	Exercise 3- AFO + STU	X2
No. of shots	35	1	0



No. of Bounces: 0

Both hit- 100%	Exercise 3- NU	X2
No. of shots	18	0	0



No. of Bounces: 0

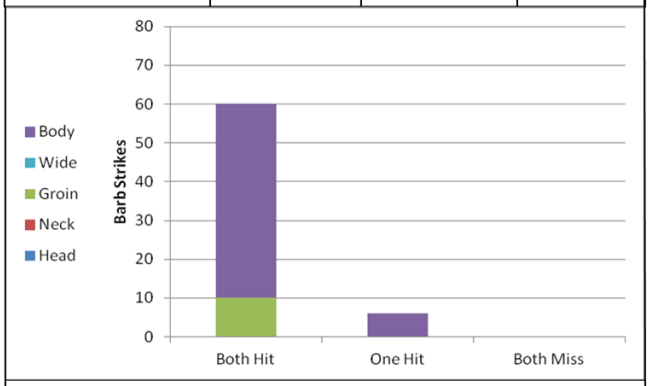
Exercise 4: Target moving sideways

Purpose: The aim of this exercise was to determine the accuracy and handling characteristics of each Taser when fired at a target moving sideways.

Action: This exercise involved a moving target which was an operative donned in a Taser training suit and the Taser fired the blue non-conductive training cartridges. The target stepped into a doorway and then out of it again. The Taser was loaded and in the ready position. On command, the target moved into the doorway and the officer was instructed to fire as quickly and as safely as possible at the moving target, using the laser sights, before it moved out of the doorway. The distance between the officer and the target was 4 m (13 ft) using the laser sights. The exercise was repeated three times for each model of Taser with the subject entering the doorway from different sides each time.

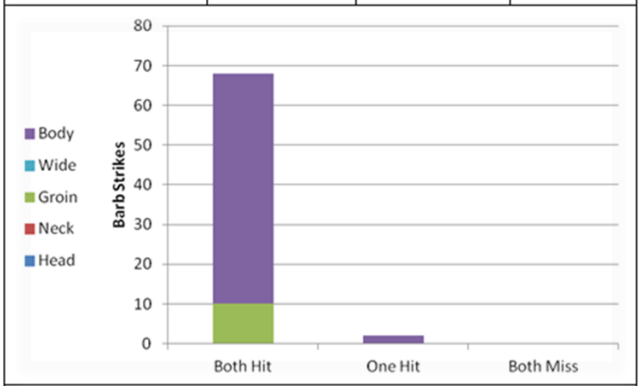
Results: Twelve Taser-trained officers each fired three shots with each model of Taser. Six non-Taser-trained officers fired three shots with the X2.

Both hit- 83%	Exercise 4- AFO + STU	X26
No. of shots	30	6	0



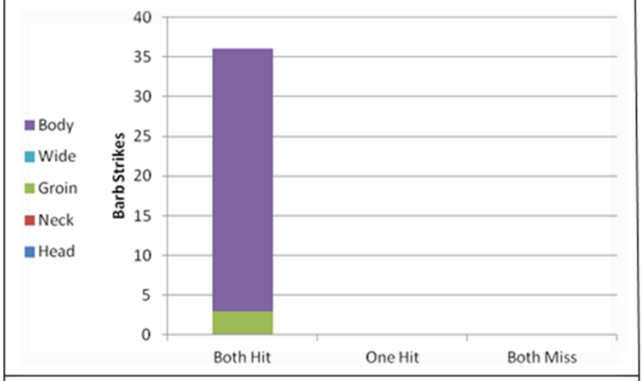
No. of Bounces: 1

Both hit- 94%	Exercise 4- AFO+STU	X2
No. of shots	34	2	0



No. of Bounces: 0

Both hit- 100%	Exercise 4- NU	X2
No. of shots	18	0	0



No. of Bounces: 0

Exercise 5: Advancing target

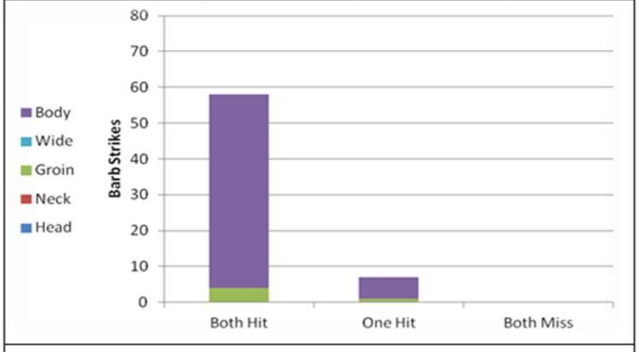
Purpose: The aim of this exercise was to determine the accuracy and handling characteristics of each Taser when fired at a target advancing towards the officer.

Action: This exercise involved a moving target which was an operative donned in a Taser training suit and the Taser fired the blue non-conductive training cartridges. The test started with the target at 9 m (30 ft) from the officer and the Taser loaded and holstered. On command, the target began to advance at a steady pace and the officer drew the Taser. When the officer felt that the target was both in range and a threat they fired at the target using the laser sights. As soon as the barbs struck the target they stopped advancing and adopted the kneeling position.

The X2 is fitted with auto-shut-off battery options. To test this feature the exercise was followed up to the first shot until the audible beep sounded. The instructor shouted “arc” and the target then stood and continued to advance. The officer then had to re-apply the Taser. The exercise was repeated three times for each model of Taser.

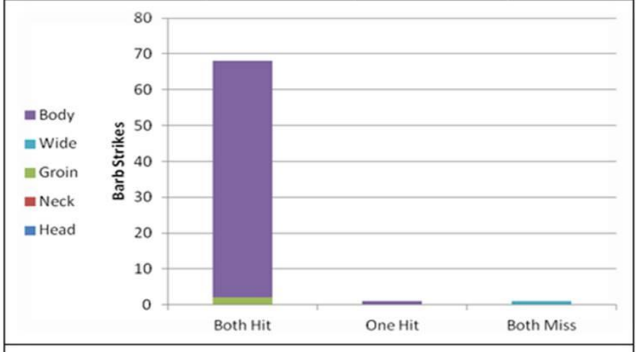
Results: Twelve Taser-trained officers each fired three shots with each model of Taser. Six non-Taser-trained officers fired three shots with the X2.

Both hit- 81%	Exercise 5- AFO+STU	X26
No. of shots	29	7	0



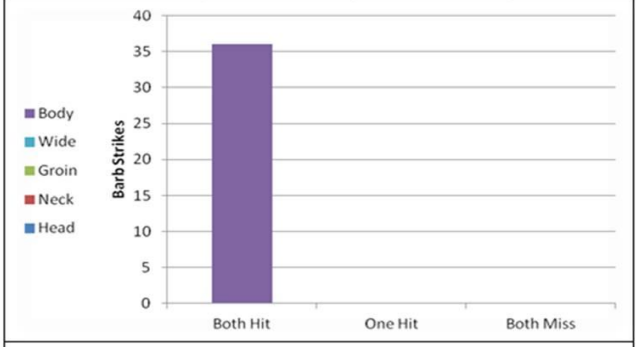
No. of Bounces: 5

Both hit- 94%	Exercise 5- AFO+ STU	X2
No. of shots	34	1	1



No. of Bounces: 2

Both hit- 100%	Exercise 5- NU	X2
No. of shots	18	0	0



No. of Bounces: 0

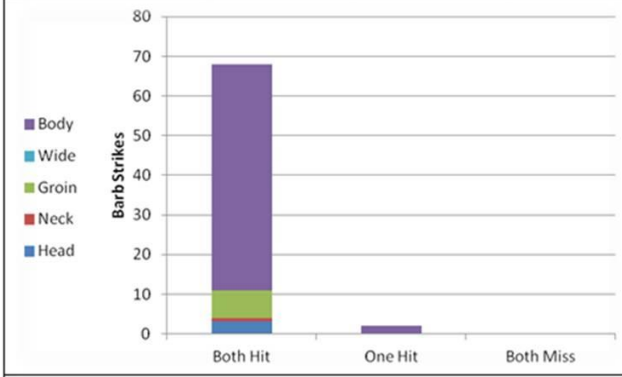
Exercise 6: Iron sights

Purpose: The aim of this exercise was to determine the accuracy and handling characteristics of each Taser when fired under ideal conditions (static, standing, face on) without using the laser sights.

Action: The Taser was loaded and in the ready position. On command the officer raised the Taser and fired at the target from a distance of 4 m (13 ft) without using the laser sights. The officer was instructed to do this as quickly as possible. The exercise was repeated three times for each model of Taser.

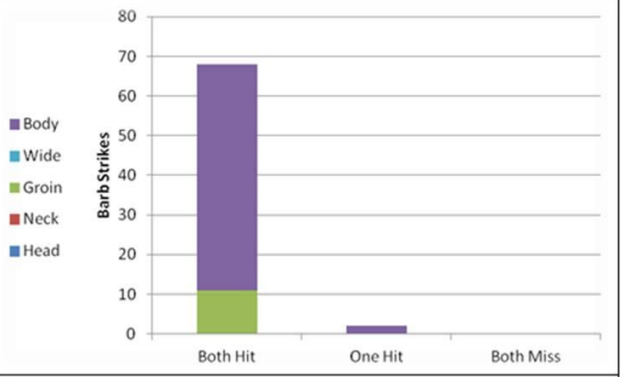
Results: Twelve Taser-trained officers each fired three shots with each model of Taser. Six non-Taser-trained officers fired three shots with the X2.

Both hit- 94%	Exercise 6- AFO+STU		X26
No. of shots	34	2	0



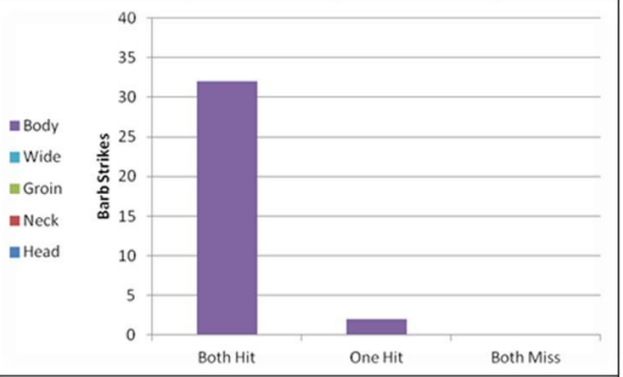
No. of Bounces: 1

Both hit- 94%	Exercise 6- AFO+STU		X2
No. of shots	34	2	0



No. of Bounces: 0

Both hit- 89%	Exercise 6- NU		X2
No. of shots	16	2	0



No. of Bounces: 0

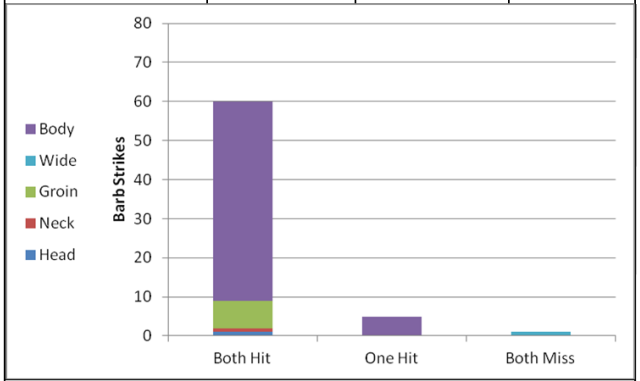
Exercise 7: Target sideways, no laser sights

Purpose: The aim of this exercise was to determine the accuracy and handling characteristics of each Taser when fired at a target lying on the floor without the use of the laser sights.

Action: The Taser was loaded and in the ready position. On command the officer raised the Taser and fired at the target from a distance of 4 m (13 ft) without using the laser sights. The officer was instructed to do this as quickly as possible. The exercise was repeated three times for each model of Taser.

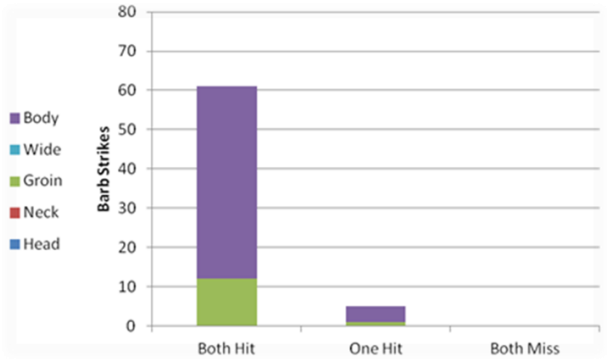
Results: Twelve Taser-trained officers each fired three shots with each model of Taser. Six non-Taser-trained officers fired three shots with the X2.

Both hit- 83%	Exercise 7- AFO+STU	X26
No. of shots	30	5	1



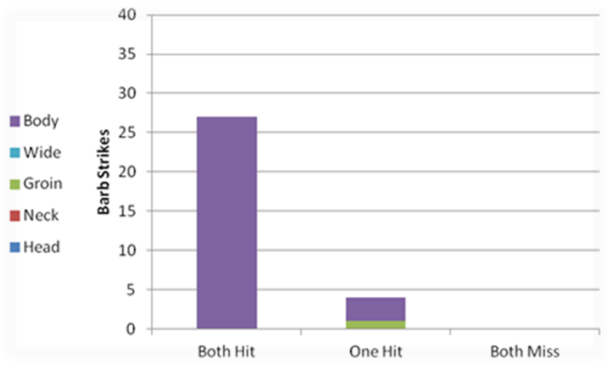
No. of Bounces: 0

Both hit- 86%	Exercise 7- AFO+STU	X2
No. of shots	31	5	



No. of Bounces: 0

Both hit- 78%	Exercise 7- NU	X2
No. of shots	14	4	0



No. of Bounces: 0

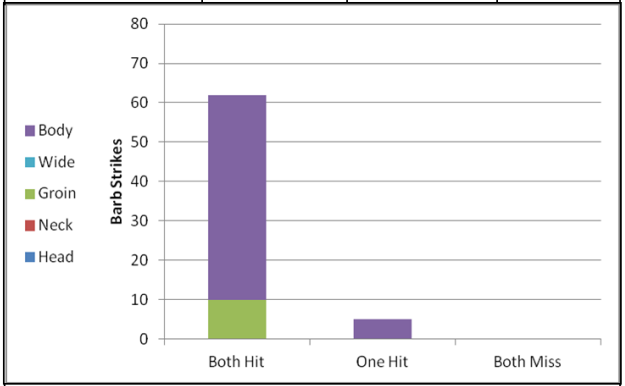
Exercise 8: Target sideways, laser sights

Purpose: The aim of this exercise was to determine the accuracy and handling characteristics of each Taser when fired at a target lying on the floor using the laser sights.

Action: The Taser was loaded and in the ready position. On command the officer raised the Taser and fired at the target from a distance of 4 m (13 ft) using the laser sights. The officer was instructed to do this as quickly as possible. The exercise was repeated three times for each model of Taser.

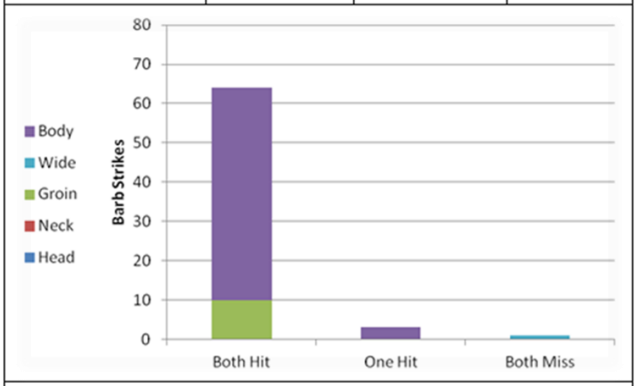
Results: Twelve Taser-trained officers each fired three shots with each model of Taser. Six non-Taser-trained officers fired three shots with the X2.

Both hit- 86%	Exercise 8- AFO+STU	X26
No. of shots	31	5	0



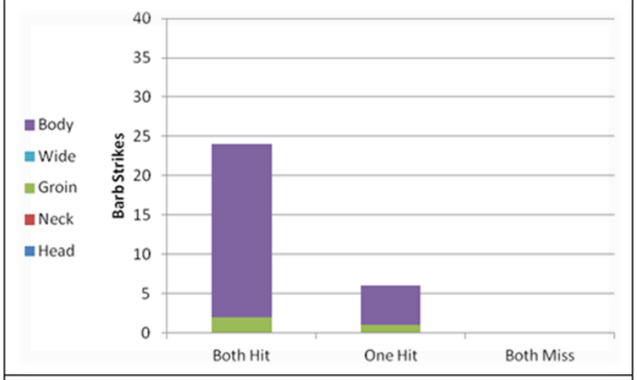
No. of Bounces: 0

Both hit- 89%	Exercise 8- AFO+STU	X2
No. of shots	32	3	1



No. of Bounces: 0

Both hit- 67%	Exercise 8- NU	X2
No. of shots	12	6	0



No. of Bounces: 0

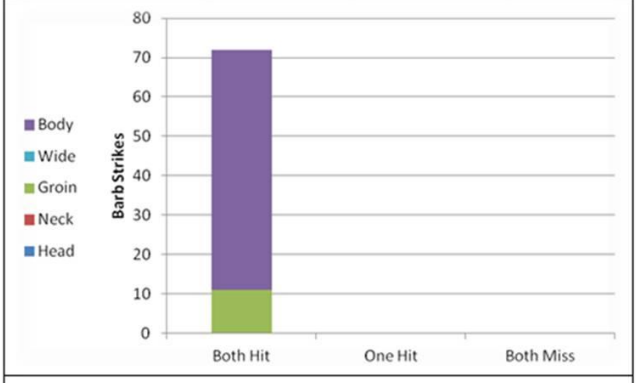
Exercise 9: Target too close

Purpose: The aim of this exercise was to determine the accuracy and handling characteristics of each Taser when fired at a standing, static target that was too close to the officer using the laser sights.

Action: The test started with the officer 1 m (3.25 ft) from the target. The Taser was loaded and in the ready position. On command the officer raised the Taser, stepped backwards and fired the Taser from the hip using the laser sights. The officer was instructed to do this as quickly as possible. The exercise was repeated three times for each model of Taser.

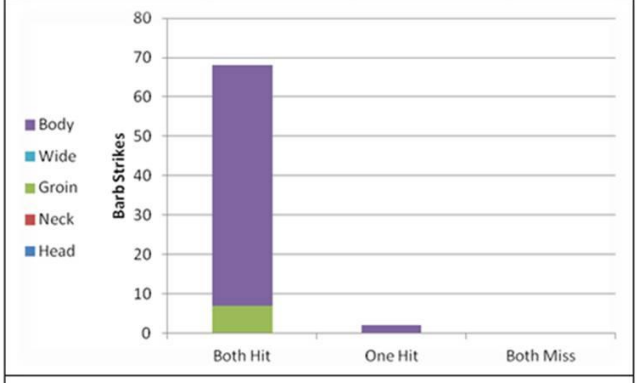
Results: Twelve Taser-trained officers each fired three shots with each model of Taser. Six non-Taser-trained officers fired three shots with the X2.

Both hit- 100%	Exercise 9- AFO+STU		X26
No. of shots	36	0	0



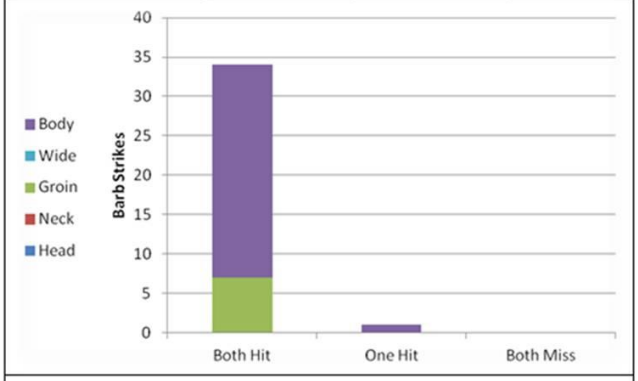
No. of Bounces: 0

Both hit- 94%	Exercise 9- AFO+STU		X2
No. of shots	34	2	0



No. of Bounces: 0

Both hit- 94%	Exercise 9- NU		X2
No. of shots	17	1	0



No. of Bounces: 0

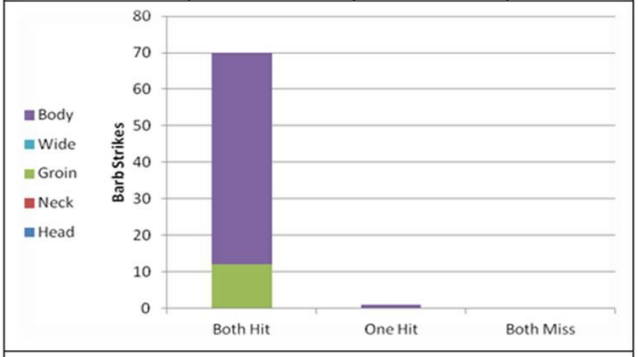
Exercise 10: Three shot

Purpose: The aim of this exercise was to compare the loading/unloading characteristics of each Taser to assess how this affected the speed at which the Taser could be fired at a standing, static target when multiple shots (3) were required using the laser sights.

Action: The Taser was loaded and in the ready position. On command the officer raised the Taser and fired at the target from a distance of 4 m (13 ft) using the laser sights. The X26 was reloaded from the grip (XDPM) for the second shot and third cartridge from a bench alongside the firer. Both bays of the X2 were fired and the third cartridge was loaded from a bench. The officer was instructed to do this as quickly and as safely as possible. The exercise was repeated three times for each model of Taser.

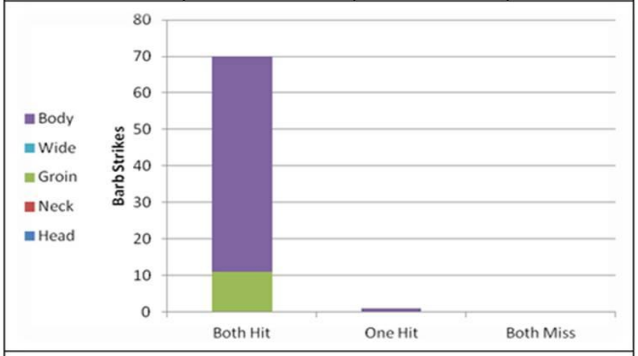
Results: Twelve Taser-trained officers each fired nine shots with each model of Taser. Six non-Taser-trained officers fired nine shots with the X2.

Both hit- 97%	Exercise 10- AFO+STU		X26
No. of shots	35	1	0



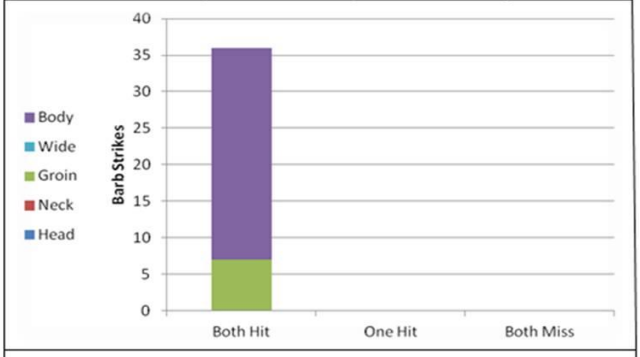
No. of Bounces: 0

Both hit-97%	Exercise 10- AFO+STU		X2
No. of shots	35	1	0



No. of Bounces: 0

Both hit- 100%	Exercise 10- NU		X2
No. of shots	18	0	0



No. of Bounces: 0

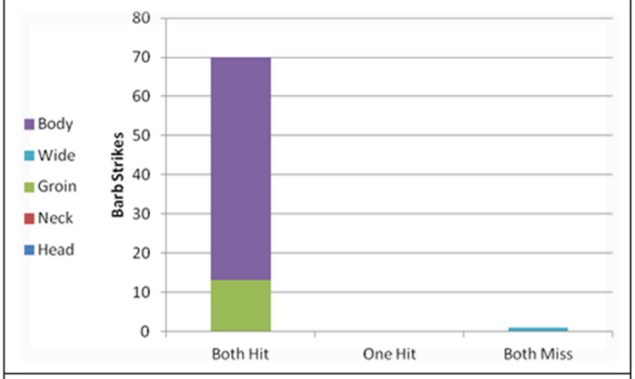
Exercise 11: Shield

Purpose: The aim of this exercise was to determine the accuracy and handling characteristics of each Taser when fired around a public order shield using the laser sights.

Action: The Taser was loaded and holstered. The shield officer took position behind the shield at a distance of 4 m (13 ft) from the target. The Taser officer took up position alongside the shield officer and drew their Taser to the ready position. On command, using the shield as cover, the Taser officer fired at the stationary target using the laser sights. The officer was instructed to do this as quickly as possible. The exercise was repeated three times for each model of Taser with the Taser officer alternating between strong hand to weak hand after each shot.

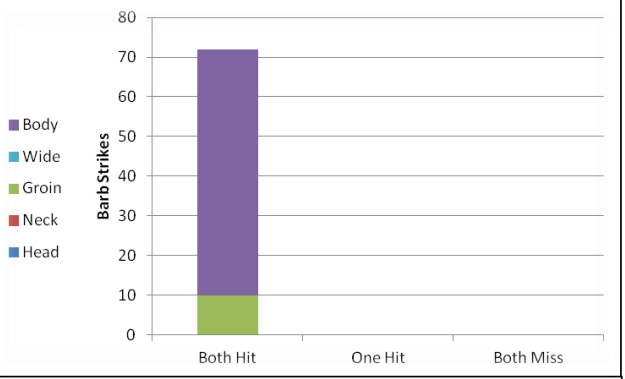
Results: Twelve Taser-trained officers each fired three shots with each model of Taser. Six non-Taser-trained officers fired three shots with the X2.

Both hit- 97%	Exercise 11- AFO+STU	X26
No. of shots	35	0	1



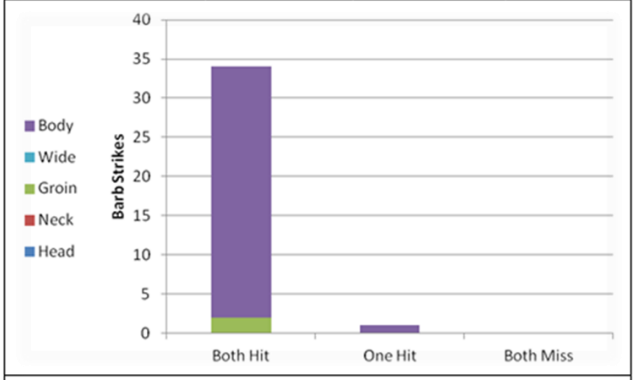
No. of Bounces: 0

Both hit-100%	Exercise 11- AFO+STU	X2
No. of shots	36	0	0



No. of Bounces: 0

Both hit- 94%	Exercise 11- NU	X2
No. of shots	17	1	0



No. of Bounces: 0

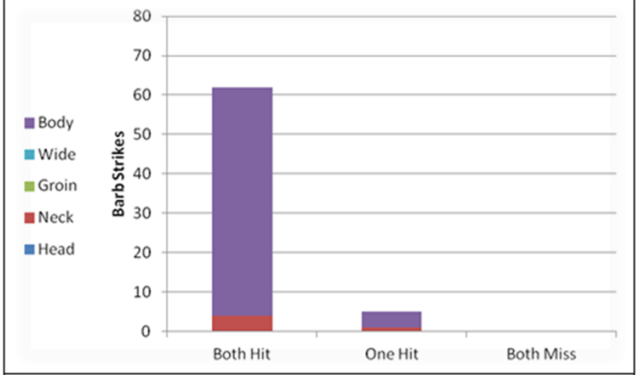
Exercise 12: Angled drive stun (X26), cross-connect (X2)

Purpose: The aim of this exercise was to determine the accuracy and handling characteristics of each Taser using the angled drive stun and cross-connect technique to a standing, static target using the laser sights.

Action: The test started with the officer 1 m (3.25 ft) from the target. The Taser was loaded and in the ready position. For the X26, on command, the officer raised the Taser and fired at the upper part of the torso and then applied the fired cartridge to the lower leg area. For the X2, on command, the officer raised the Taser and fired bay 1 at the upper part of the torso and then fired bay 2 at the lower leg area. The officer was instructed to do this as quickly as possible. The exercise was repeated three times for each model of Taser.

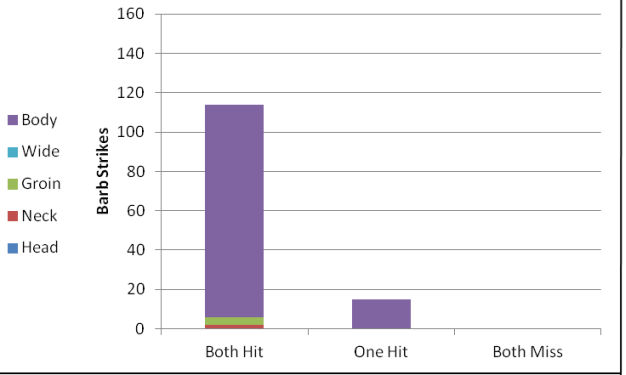
Results: Twelve Taser-trained officers each fired three shots with each model of Taser. Six non-Taser-trained officers fired three shots with the X2.

Both hit- 86%	Exercise 12- AFO+STU	X26
No. of shots	31	5	0



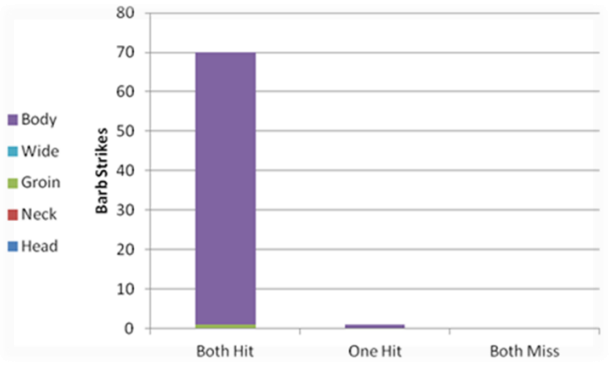
No. of Bounces: 0

Both hit- 79%	Exercise 12 AFO+STU	X2
No. of shots	57	15	0



No. of Bounces: 0

Both hit- 97%	Exercise 12- NU	X2
No. of shots	35	1	0



No. of Bounces: 0

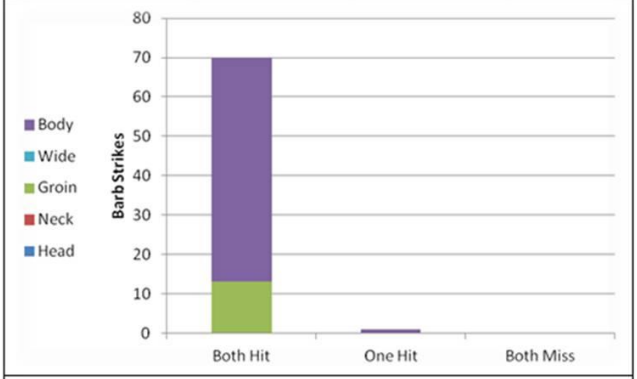
Exercise 13: Show of strength

Purpose: The aim of this exercise was to determine the accuracy and handling characteristics of each Taser when demonstrating a show of strength by sparking the Taser before firing at a standing, static target using the laser sights.

Action: The Taser was loaded and in the ready position with the officer 4 m (13 ft) from the target. For the X26, on command, the officer raised the Taser red dotting the target, unloaded the cartridge, sparked the Taser, reloaded the cartridge and then fired at the target using the laser sights. For the X2 on command, the officer raised the Taser red dotting the target, sparked the Taser using the arc switch, and then fired at the target using the laser sights. The officer was instructed to do this as quickly as possible. The exercise was repeated three times for each model of Taser.

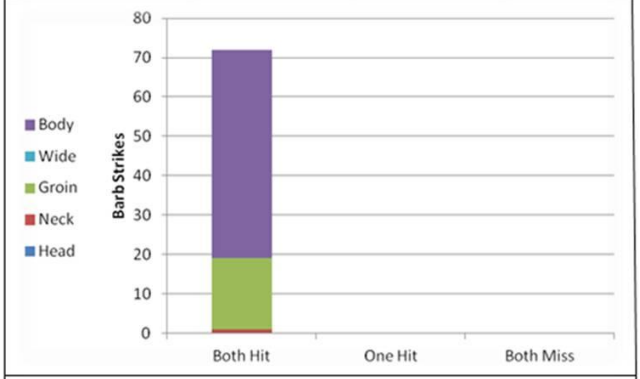
Results: Twelve Taser-trained officers each fired three shots with each model of Taser. Six non-Taser-trained officers fired three shots with the X2.

Both hit- 97%	Exercise 13- AFO+STU		X26
No. of shots	35	1	0



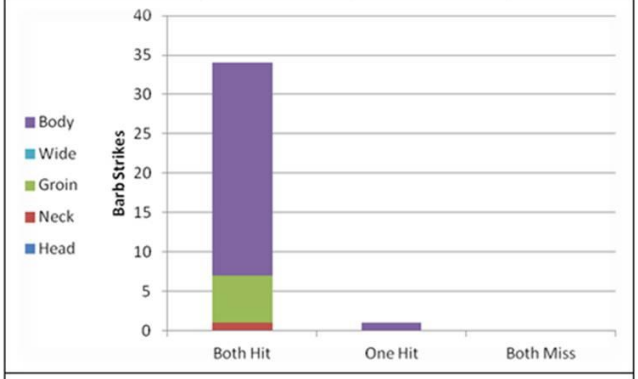
No. of Bounces: 0

Both hit-100%	Exercise 13- AFO+ STU		X2
No. of shots	36	0	0



No. of Bounces: 0

Both hit- 94%	Exercise 13- NU		X2
No. of shots	17	1	0



No. of Bounces: 0

APPENDIX E – User handling trial questionnaire and responses

Participants (CAST: circle those that apply)

Authorised Firearms Officer / Specially Trained Unit / New Users

OFFICER I.D.

Date: ……

After completing the scenario exercises for each conducted energy device (CED) every participating officer will be asked to complete the following questionnaire in order to collect their views.

Once completed, all the questionnaires will be collated and the scores from all officers for each aspect for each device will be averaged. The total averaged scores will then converted into a percentage as set out in the published evaluation methodology (Appendix 1).

Where appropriate, the options to score the questions are:

5 Strongly Agree

4 Tend to Agree

3 Tend to Disagree

2 Strongly Disagree

1 Don't Know

Please score each device

Q1. The device is accurate and discriminating. (CED-OR(TE)-04)

CED 1	

Q2. The device could be used to target an individual within a group. (CED-OR(TE)-04)

CED 1	

Q3. The device could be used effectively against a moving target. (CED-OR(TE)-04)

CED 1	

Q4. The device is appropriate for use in all officer roles:

Q4a. What role(s) are you currently competent? (**Tick all that apply**)

1. Uniform response officer	
2. PSU	
3. AFO/ARV	
4. SFO	
5. Motorcyclist	
6. CPO	
7. Surveillance	
8. Armed Surveillance/SFIC/MASTS	
9. Other…(please specify)	

Q4b. The device is suitable for the role(s) selected above? (**Score all that apply**)

	1	2	3	4	5	6	7	8	9
CED 1									

Q5. The device is easy to point and aim. (CED-OR(TE)-04), (CED-OR(TE)-06)

CED 1	

Q6. The device is easy to load and unload. (CED-OR(TE)-06)

CED 1	

Q7. The device is easy to operate, including the safety switch and trigger. (CED-OR(TE)-06)

CED 1	

Q8. The device can be used accurately without the use of laser sights. (CED-OR(TE)-04)

CED 1	

Q9. The device is safe to use without risk of electric shock to the officer. (CED-OR(TE)-02)

CED 1	

Q10. The device could be used in confined spaces when the subject is too close. (CED-OR(TE)-06)

CED 1	

Q11. After completion of the exercises, I felt confident in handling and using this device.

CED 1	

Q12. The device fits well in the hand so it can be gripped firmly to facilitate retention in the event of a struggle.

CED 1	

Q13. The device would be suitable for use in the dark or subdued lighting conditions. (CED-OR(TE)-03)

CED 1	

Q14. The device could not easily be discharged unintentionally. (CED-OR(TE)-06)

CED 1	

Q15. The device was easy to reset after the auto-shut-off. (CED-OR(TE)-11)

CED 1	

Q16. The training cartridges (used against the subject in suit) were a good simulation of the operational cartridge and performed in a similar manner. (CED-OR(TE)-19)

CED 1	

Q17. The training cartridges were readily distinguishable from operational cartridges. (CED-OR(TE)-19)

CED 1	

END

Summary of questionnaire responses

Q1. This device is accurate and discriminating (CED-OR(TE)-04)

	AFO X2	STU X2	NU X2	AFO X26	STU X26
Strongly agree	4	6	3	1	2
Tend to agree	2		3	3	4
Tend to disagree				2	
Strongly disagree					
Don't know					

Q2. The device could be used to target an individual within a group (CED-OR(TE)-04)

	AFO X2	STU X2	NU X2	AFO X26	STU X26
Strongly agree	3	5	3		
Tend to agree	3	1	2	2	5
Tend to disagree			1	3	1
Strongly disagree				1	
Don't know					

Q3. The device could be used effectively against a moving target (CED-OR(TE)-04)

	AFO X2	STU X2	NU X2	AFO X26	STU X26
Strongly agree	5	6	4	1	1
Tend to agree	1		2	1	5
Tend to disagree				4	
Strongly disagree					
Don't know					

Q5. The device is easy to point and aim (CED-OR(TE)-04), (CED-OR(TE)-06)

	AFO X2	STU X2	NU X2	AFO X26	STU X26
Strongly agree	5	6	4	2	5
Tend to agree	1		2	2	1
Tend to disagree				2	
Strongly disagree					
Don't know					

Q6. The device is easy to load and unload (CED-OR(TE)-06)

	AFO X2	STU X2	NU X2	AFO X26	STU X26
Strongly agree		1	2	3	5
Tend to agree	3	3	4	1	1
Tend to disagree	3	1		2	
Strongly disagree		1			
Don't know					

Q7. The device is easy to operate, including the safety switch and trigger (CED-OR(TE)-06)

	AFO X2	STU X2	NU X2	AFO X26	STU X26
Strongly agree	4	6	3	3	6
Tend to agree	1		3	3	
Tend to disagree	1				
Strongly disagree					
Don't know					

Q8. The device can be used accurately without the use of laser sights (CED-OR(TE)-04)

	AFO X2	STU X2	NU X2	AFO X26	STU X26
Strongly agree	3	4	3	3	2
Tend to agree	3	1	2	2	2
Tend to disagree		1	1	1	1
Strongly disagree					1
Don't know					

Q9. The device is safe to use without risk of electric shock to the officer (CED-OR(TE)-02)

	AFO X2	STU X2	NU X2	AFO X26	STU X26
Strongly agree	4	5	3	1	1
Tend to agree	2	1	3	4	2
Tend to disagree				1	3
Strongly disagree					
Don't know					

Q10. The device could be used in confined spaces when the subject is too close (CED-OR(TE)-06)

	AFO X2	STU X2	NU X2	AFO X26	STU X26
Strongly agree	4	6	3	1	2
Tend to agree	2		3	4	3
Tend to disagree				1	1
Strongly disagree					
Don't know					

Q11. After the completion of the exercises, I felt confident in handling and using this device

	AFO X2	STU X2	NU X2	AFO X26	STU X26
Strongly agree	6	6	5	3	5
Tend to agree			1	3	1
Tend to disagree					
Strongly disagree					
Don't know					

Q12. The device fits well in the hand so it can be gripped firmly to facilitate retention in the event of struggle

	AFO X2	STU X2	NU X2	AFO X26	STU X26
Strongly agree	1	2	3	2	6
Tend to agree	1	1	2	3	
Tend to disagree	3	2	1	1	
Strongly disagree	1	1			
Don't know					

Q13. This device would be suitable for use in the dark or subdued light conditions (CED-OR(TE)-03)

	AFO X2	STU X2	NU X2	AFO X26	STU X26
Strongly agree	4	3	4	2	4
Tend to agree	2	3	2	4	2
Tend to disagree					
Strongly disagree					
Don't know					

Q14. The device could not easily be discharged unintentionally (CED-OR(TE)-06)

	AFO X2	STU X2	NU X2	AFO X26	STU X26
Strongly agree	4	5	3	3	4
Tend to agree	2	1	2	3	2
Tend to disagree					
Strongly disagree			1		
Don't know					

Q15. The device was easy to reset after the auto-shut-off (CED-OR(TE)-11)

	AFO X2	STU X2	NU X2	AFO X26	STU X26
Strongly agree	4	6	4	n/a	n/a
Tend to agree	2		2		
Tend to disagree					
Strongly disagree					
Don't know					

Q16. The training cartridges (used against the subject in suit) were a good simulation of the operational cartridge and performed in a similar manner (CED-OR(TE)-19)

	AFO X2	STU X2	NU X2	AFO X26	STU X26
Strongly agree	5	6	5	3	3
Tend to agree	1		1	3	2
Tend to disagree					1
Strongly disagree					
Don't know					

Q17. The training cartridges were readily distinguishable from operational cartridges (CED-OR(TE)-19)

	AFO X2	STU X2	NU X2	AFO X26	STU X26
Strongly agree	4	4	3	5	6
Tend to agree	2	1	1	1	
Tend to disagree		1	2		
Strongly disagree					
Don't know					

APPENDIX F – Laser measurements

Public Health England

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8 January 2015

Re: Laser Measurements on Taser Devices

Public Health England was asked to assess the lasers attached to three types of Taser Devices and to provide an opinion on compliance with the current standard on laser safety – BS EN 60825-1: 2014 "Safety of laser products – Part 1: Equipment classification and requirements".

An assessment was previously carried out by the then National Radiological Protection Board in January 2003 on five M26 and four M18L Tasers and the results were summarised in the then Police Scientific Development Branch report PSDB 19/05.

Four each of three types of Taser device were supplied for assessment: X26, X26P and X2. The X26 and X26P both emit a single laser beam when armed. The X2 emitted two beams to provide a better indication of where the barbs will hit. The upper beam was continuous wave and the lower beam was modulated. The Tasers provided for assessment are shown in Figure 1.

Figure 1: Taser devices provided for assessment, left to right: X2, X26P and X26 models.

Method

The wavelength of the laser beams was determined using an Ocean Optics HR4000 CCD array spectroradiometer, serial number 4C622, coupled via a 600µm UV/SR fibre to a Bentham D7_H_SMA global input optic, serial number 11447. The system was calibrated for wavelength scale using a low pressure mercury lamp.

The wavelength determined from the spectroradiometer was used to ensure that the laser power meters (Coherent PowerMax PC, USB UV/VIS Wand, serial number 0056C14R and Coherent FieldMaster, serial number GF34, with LM2 detector, serial number 9411) were set to the appropriate calibration factor. The peak radiant power of the modulated beams from the X2 Taser devices was determined using a Coherent LabMAX TOP, serial number 0514H11R, with an LM-2 VIS detector, serial number 1053B06. The laser beams were confirmed to be monochromatic.

The temporal information from the modulated output of the X2 Taser devices was assessed using a Thorlab DET36A Si biased detector with a National Instruments NI6211 Digital Acquisition Card.

Results

The results are presented in table 1, below.

Table 1: Laser beam characteristics

Taser model	Serial Number		Wavelength (nm)	Maximum Power (mW)[1]
X26	X00/495036		651	2.97
	X00/486443		652	3.08
	X00/057916		653	2.69
	X00/572203		652	3.02
X26P	X13/000V6P		652	2.56[3]
	ZZX/1301C2		654	2.81[3]
	X13000TY1		651	2.59[3]
	Z13000TE0		651	2.75[3]
X2	X30000V46	Top beam	653	2.63
		Bottom beam[2]	653	2.45
	X30000V6Y	Top beam	653	2.56
		Bottom beam[2]	654	2.78
	X30000V5M	Top beam	652	2.49
		Bottom beam[2]	652	2.58
	X30000V69	Top beam	651	2.48
		Bottom beam[2]	652	2.12

Notes

[1]The uncertainty on the Maximum Power measurements is considered to be less than 5%.

[2]The radiant power quoted for the modulated beams is the maximum value, excluding the spike (see Figure 2).

[3]These values were not constant with time and represent the maximum values recorded.

The lower laser beam on the Taser X2 was modulated at approximately 4 Hz. The modulated pulse structure is presented in Figure 2 for device serial number X30000V5M. It can be seen that there is a short-duration overshoot at the start of each pulse. This structure was consistent across the four X2 Tasers. However, this was not considered photobiologically significant.

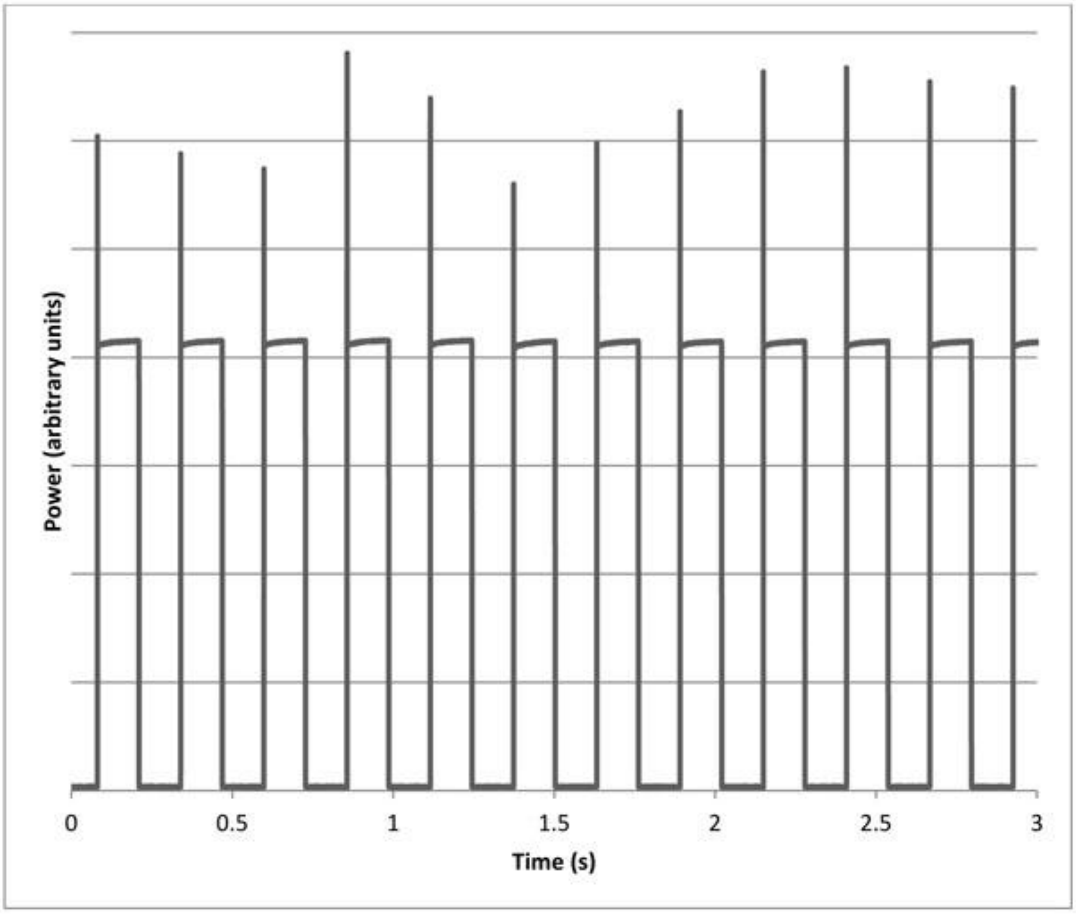

Figure 2: Laser beam power as a function of time for X2 Taser serial number X30000V5M

Compliance with BS EN 60825-1: 2014

BS EN 60825-1: 2014 is identical to EN 60825-1: 2014 and IEC 60825-1: 2014. Therefore, it would be reasonable to expect laser products placed on the international market to comply with the requirements of these standards. However, since the Taser devices are battery-powered units, they are not required to comply with the requirements of the Low Voltage Directive, under which EN 60825-1 is harmonised.

This assessment does not consider other Directives that the Taser devices would need to comply with for CE marking.

The primary market for the Taser devices is understood to be in the United States. Therefore, the products have been manufactured in compliance with the US Food and Drug Administration (FDA) Federal Product Performance Standard 21 CFR §1040.10 "Performance Standards for Light-Emitting Products – Laser products". Manufacturers have the option to use the FDA Laser Notice No. 50, which permits the sale of products in the United States if they comply with many of the requirements of IEC 60825-1, particularly allowing the use of labelling and information to the user in compliance with the international standard.

An example laser safety label is show in Figure 3. The label was similar on all three types of Taser.

Figure 3: Laser safety warning label on a Taser X2

It should be noted that the structure of the BS EN 60825-1 has changed since the previous assessment was carried out. Therefore, the clause numbers quoted below are different to those stated in PSDB 19/05.

Compliance with the requirements of BS EN 60825-1 was considered to be common across the three models of Taser device and is summarised in table 2. The clauses covered are considered to be the appropriate ones for the Taser devices assessed.

Table 2: Compliance with BS EN 60825-1

Clause	Requirement (taken from Standard, including references to Clauses and Figures in the Standard)	Comment
5.3	Determination of the class of the laser product	The manufacturer has classified the devices under the requirements of the FDA Federal Product Performance Standard as class IIIa. The measured radiant power levels reported in Table 1 suggest that the devices are Class 3R.
6.9	Each laser product shall have controls located so that adjustment and operation do not require exposure to laser radiation equivalent to Class 3R, Class 3B or Class 4.	Requirement met. The Tasers are operated from behind the laser aperture(s).
7.1	Each laser product shall carry label(s) in accordance with the requirements of the following clauses. The labels shall be durable, permanently affixed, legible, and clearly visible during operation, maintenance or service, according to their purpose. They shall be so positioned that they can be read without the necessity for human exposure to laser radiation in excess of the AEL for Class 1. Text borders and symbols shall be black on a yellow background except for Class 1, where this colour combination need not be used. The wording of labels shown in Clause 7 is recommended but not mandatory. Other wording that conveys the same meaning (including warning labels per earlier editions of IEC 60825-1) may be substituted.	The Taser devices carry warning labels that appear to be "durable, permanently affixed and legible". However, they are located on the under-side of the devices, which means they are not visible during operation. The labels can be read without the necessity for human exposure to laser radiation. The labels do not comply with the colour requirements.

Clause	Requirement (taken from Standard, including references to Clauses and Figures in the Standard)	Comment
7.5	Each Class 3R laser product shall have affixed a warning label (Figure 3) and an explanatory label (Figure 4) bearing the words: LASER RADIATION AVOID DIRECT EYE EXPOSURE CLASS 3R LASER PRODUCT	The laser starburst warning label (Figure 3) is not displayed. The wording "Laser Radiation – Avoid Direct Eye Exposure" is included, but not in the Figure 4 (of BS EN 60825-1) format. The correct laser class is not indicated.
7.8	Each Class 3R, Class 3B and Class 4 laser product shall have affixed a label close to each aperture through which laser radiation in excess of the AEL for Class 1 or Class 2 is emitted. The label(s) shall bear the words: LASER APERTURE or APERTURE FOR LASER RADIATION or AVOID EXPOSURE – LASER RADIATION IS EMITTED FROM THIS APERTURE	The aperture(s) are not marked. However, there is a red arrow on the label (see Figure 2), which may be the intended aperture label.
7.9	The name and publication date of the standard to which the product was classified shall be included on the explanatory label, on the labels shown in 7.2 to 7.7 or elsewhere in close proximity on the product. Each laser product, except those of Class 1, shall be described on the explanatory label (Figure 4) or on the labels shown in 7.2 to 7.7 by a statement of the maximum output of laser radiation (see definition 3.58), the pulse duration (if appropriate) and the emitted wavelength(s).	Although inappropriate for compliance with BS EN 60825-1, the devices do have the name of the standard on the label (CFR 1040.10 & 1040.11). The publication date is not included. The maximum output and the wavelength ranges are stated.
8.1 a)	Adequate instructions for proper assembly, maintenance, and safe use, including clear warnings concerning precautions to avoid possible exposure to hazardous laser radiation and description of the classification limitations, if appropriate	Not given in the manual.
8.1 c)	For laser radiation levels above the AEL of Class 1, a description of any radiation pattern(s) emitted from the protective housing during the performance of operation and maintenance procedures. Where applicable, this shall include a statement in appropriate units of: • wavelength, • beam divergence, • pulse duration and repetition rate (or description of irregular pulse pattern), • maximum power or energy output.	The manual only states the wavelength.
8.1 g)	Legible reproductions (black mono tone or in the appropriate colours stated in Clause 7) of all required labels and hazard warnings to be affixed to the laser product or provided with the laser product. The corresponding position of each label affixed to the product shall be indicated or, if provided with the product, a statement that such labels could not be affixed to the product but were supplied with the product and a statement of the form and manner in which they were supplied shall be provided.	Not provided in the manual.

Electromagnetic Fields

On June 29th, 2013, the European Commission published Directive 2013/35/EU on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents

(electromagnetic fields) (20th individual Directive within the meaning of Article 13(1) of Directive 89/391/EEC). Public Health England was contracted to draft the non-binding guide to the Directive.

Member States have until 1st July 2016 to transpose the Directive into national legislation. There is no derogation from the requirements of the Directive for police officers, although the Directive allows Member States to grant derogations to specific sectors for specific activities provided it can be demonstrated that workers are adequately protected.

The Directive only applies to workers and will result in a duty on the employer to assess risks from exposure of workers to electromagnetic fields. This assessment may require measurements if data does not already exist. In order to assist police forces who may use the Tasers, it would be beneficial to provide an assessment of the likely exposure of the officer discharging the Taser and any officers who may be close by. Public Health England may be able to assist with this assessment.

Conclusions

The lasers installed in the assessed Tasers are similar to those in the Taser devices assessed previously and the conclusions remain the same. This includes a disclaimer that the devices were assessed as supplied and were not tested under reasonably foreseeable failure conditions that may increase the output of the lasers.

The Tasers should be considered Class 3R laser products, as defined in BS EN 60825-1: 2014. This laser class is similar to class IIIa with the Danger warning as marked on the devices. To avoid confusion, it is suggested that the manufacturer should be asked to supply the equipment with labelling that complies with IEC 60825-1: 2014, which is identical to the British Standard.

The data in the manual was incomplete.

The laser beams exceed the exposure limits for the eye given in the Artificial Optical Radiation Directive, as implemented in the UK as the Control of Artificial Optical Radiation at Work Regulations 2010. Therefore, it is important that the manufacturer's guidance on training is heeded and that the laser beams are not directed into the eyes of those who may be at work. This is likely to be particularly important during training sessions. The exposure limits are set at levels below which eye damage will not occur. Although any accidental exposure of the eye to the laser beams from one of the Taser devices could exceed the exposure limit, it is still considered that the risk of injury is extremely small. However, if a person is exposed to the beam at low ambient light levels, the beam illuminance is sufficient to cause temporary visual impairment.

If accidental eye exposure does occur, there are specific post-incident duties on the employer specified in the Control of Artificial Optical Radiation at Work Regulations 2010. It is suggested that generic guidance could be developed for police forces on what to do in the event of actual or likely exposure of someone's eyes.

Yours sincerely

<redacted>

Glossary of terms

ACPO	Association of Chief Police Officers (now NPCC)
AFID	Anti-felon identification
AFO	Authorised Firearms Officer
APPM	Auto-shutdown Performance Power Magazine used for the X2
Arc	Activation of the arcing of the Taser or sparking
ARV	Armed response vehicle
AXON	The name of the UK distributor for TASER International
CED	Conducted energy device
CEW	Conducted energy weapon
CoP	College of Policing
DOMILL	Defence Scientific Advisory Council Sub-Committee on the Medical Implications of Less-Lethal Weapons (DOMILL) (now SACMILL)
DRDC	Defence Research and Development Canada
Dstl	Defence Scientific Technology Laboratories
EMC	Electromagnetic compatibility
IEC	International Electrotechnical Commission – the international standards and conformity assessment body for all fields of electrotechnology
LED	Light-emitting diode
LLW	Less-lethal weapons
MPS	Metropolitan Police Service
NPCC	National Police Chiefs Council
POA	Point of aim

POI	Point of impact
PPE	Personal protective equipment
PPM	Performance Power Magazine
PSU	Police Support Unit
SACMILL	Scientific Advisory Council on the Medical Implication of less-lethal weapons
SFO	Specialist Firearms Officer
SP	Smart Probe
STU	Specially Trained Unit
Taser Cycle	Five-second activation
TASER International	Manufacturer of TASER® products
Taser X2	New “smart” Taser that has a two-shot capability
Taser X26	Current model of Taser deployed by UK police
Taser X26P	New single shot ‘smart’ Taser similar to the X26
TETRA	Terrestrial Trunk Radio (formerly known as Trans-European Trunked Radio)
XDPM	Digital Power Magazine for the X26 and holds a spare cartridge for the Taser X26