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A Qualitative & Quantitative Analysis of Conducted Energy Devices: TASER X26 vs. Stinger S200

A report to the National Institute of Justice

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MANUFACTURER COMMENTS

TASER® International Inc. and Stinger™ Systems were provided the opportunity to comment on the draft report. Their comments have been included in the appendix of this document.

Additional information about the companies and their products can be found at:

http://www.taser.com
http://www.stingersystems.com

ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

A Conductive Energy Device (CED) is a device designed to deploy electricity throughout the body of the target to temporarily cause loss of muscle control. TASER® International, the company best known today for producing CEDs, claims it provides an advanced non-lethal option for the use in law enforcement, private security and personal defense. However, recent competition by Stinger™ Systems, Inc. in the once limited field of CEDs has led many agencies to question the advantages and disadvantages of the competing products.

As a less-lethal weapon, a CED with projectile probes can be very effective. These devices can incapacitate a subject through the use of electrical shock, generally allowing the user enough time to apprehend a subject, or retreat from confrontation. It has been hypothesized that the voltage produced overwhelms the attacker's nervous system, forcing their muscles to contract, causing temporary incapacitation. However, reliability is a major concern when dealing with any type of weapon system. A significant problem for law enforcement agencies that are preparing to deploy CEDs into the field is that they are required to rely on factory data, specification sheets, and company marketing in order to make the critical decision as to which system to adopt. An independent study of this electronic weapons technology was necessary to determine each product's performance and operational safety.

This report provides both a qualitative and quantitative analysis of the two weapon systems. The researchers tested both the TASER X26 and Stinger S200 weapon systems repeatedly, and documented variables including: distance to target, probe spread, probe distance to aim point, probe contact with target, and cartridge and weapon systems malfunctions. A qualitative review of the shocks received from both the TASER and Stinger weapons was conducted using fifteen volunteers. Using alligator clips to deliver the weapon's shock, the majority of people reported a much lower level of incapacitation when hit with the Stinger S200 in comparison to the TASER X26. In comparison, one individual that took a probe/barb hit claimed that the Stinger S200 was much stronger than the TASER X26 shock.

In a quantitative review of the weapon systems, this document shows the TASER X26 system to be much more reliable than its Stinger S200 counterpart, even after researchers received a replacement weapon and cartridges from Stinger due to a high incidence of malfunctions. An additional concern with the Stinger weapon system was that the Stinger S200 probes consistently broke free from their barbs in the target. The Stinger S200 system also had problems with tangled lead wire, and although the probe spread was smaller in the Stinger S200 (allowing for greater accuracy at greater distances than the TASER X26), the probes had a problem reaching the target. During testing it became clear that the lighter Stinger S200 probe penetrates deeply at close distances, but quickly loses its ability to penetrate even a soft target over greater distances.

The TASER X26 weapon system also had problems. While probe spread is important in a projectile CED to insure electrical current is traveling through a large amount of muscle mass, the TASER missed the target a significant amount of times at 20 feet, even though the tether wire was 25 feet long, due to the probe's spread angle.

Both products were also tested for durability. The TASER X26 and the Stinger S200 had similar tensile strength in the tether wires leading from the weapon to the probes. In a separate test, a number of cartridges were dropped from a height of four feet to determine their survivability. None of the TASER cartridges broke during this test; however, fourteen out of the twenty Stinger cartridges broke upon impact with a carpeted floor.

INTRODUCTION

Law enforcement agencies across the United States have adopted the TASER® as the Conducted Energy Device (CED) weapon of choice, and until recently it was the only commercially available stun-gun device for law enforcement agencies that worked by firing probes to conduct energy to a target. With the advent of Stinger™ Systems, Inc.'s Stinger S200 device, the CED marketplace now has two similar devices from which to choose. An initial review of Stinger revealed a lower purchase price than TASER, and features which may enhance accuracy and reduce liability claims.

As a result of public dollars, funds from the Department of Justice (DOJ) are being provided to local and state law enforcement agencies to purchase TASERs through community policing grants. Because of this new competition in the CED field, the DOJ has the obligation to examine other alternatives to ensure the maximum utility of the public monies being spent.

This report provides a framework which objectively and empirically examines the two CED devices so that the DOJ, and therefore law enforcement agencies that use these devices, are better informed about the devices' performance and safety attributes.

Research Problem

A CED is a device designed to deploy electricity through the body of the target to temporarily cause loss of muscle control. In the history of American law enforcement, there have been many devices that may fit this description, including "cattle prods," "stun guns," and many more. Over the past decade, however, the technology for these devices has become more user-friendly, allowing the application of electricity from the device from greater distances, with greater precision in the application of voltage.

The less lethal conductive energy device (CED) market has recently seen the introduction of a new handheld projectile stun gun in a field previously controlled by TASER International. The Stinger S200 has entered the law enforcement CED market, and is approximately the same size as the TASER X26. The Stinger S200, like the TASER X26, fires two probes and uses high voltage/low amperage electricity to disable a subject.

A significant problem for law enforcement agencies that are preparing to deploy CEDs into the field is that they are required to rely on factory data, specification sheets, and company marketing in order to make the critical decision as to which system to adopt. An independent study of this electronic weapons technology was necessary to determine the product's performance and operational safety.

Implications for the law enforcement community

At the very heart of the debate on the use of less-lethal technology to maintain peace and law and order is the philosophical belief that doing unnecessary harm to another is wrong. Less-lethal technologies offer agencies the ability to reduce threats to the public good while causing the least amount of harm. CED systems appear to offer law enforcement agencies an ideal solution. Since the large-scale deployment of CED systems on the market in the last ten years, many agencies have claimed that injuries to suspects and officers have been reduced as a result of their use. In the case of the Orange County Sheriff's Office, there has been an estimated overall 80% reported reduction in injuries (Hopkins & Beary, 2003) since CEDs were deployed to patrol officers. This reduction clearly demonstrates that Conducted Energy Devices have greatly enhanced the ability of law enforcement officers to do their job, while at the same time offering the benefits of officer safety.

The TASER International device is the most widely accepted CED on the market by law enforcement agencies. Consequently, Stinger has entered the market and offers a similar CED device that is marketed as just as effective as and less expensive than the TASER brand device. The purpose of this study, therefore, is to objectively evaluate both the TASER International and Stinger weapon systems. This is accomplished by evaluating the performance, safety, and reliability of both products.

LITERATURE REVIEW

TASER

The TASER weapon (so named because of the creator's interest in science fiction as the "Thomas A. Swift's Electric Rifle") administers an electrical charge using direct current which causes muscular dysfunction and temporary incapacitation of a suspect. Two darts are fired from the pistol-like weapon and an electrical pulse of 50,000 volts is passed into the subject's body (Laur, 2000). The darts fired from the TASER are tethered by thin wires which can reach from 15 feet (civilian model) to 35 feet (law enforcement model).

Early studies indicated this weapon's effectiveness ranged from 50% - 85% (Donnelly, 2001). Because the TASER uses compressed nitrogen for propulsion, TASER models are not classified as a firearm by the Bureau of Alcohol, Tobacco, Firearms and Explosives (BATFE), and only individual state statutes restrict ownership. TASER reports that they will not sell their law enforcement models to civilians, as civilian models that use cartridges with a shorter range (C2 model) are also available. Nevertheless, this does not preclude a civilian from owning a law enforcement model TASER if they are able to obtain one, and civilian ownership may be restricted by specific state law.

The two primary TASER models are the older, larger M26 and the newer, smaller X26 model; both models utilize a laser aiming system that activates when the weapon is turned on. The M26 TASER has AA batteries in the weapon's grip and as the power runs down on the device, the electrical shock it provides is also weakened. The M26 is rechargeable through a port in the rear of the weapon that can also be used to download deployment data. This port is covered by a rubber plug which protects against moisture entering the weapon.

In comparison, the X26 uses a digital power magazine (DPM) which is inserted and removed from the X26's grip much like a pistol magazine. The DPM acts as both the software and power supply for the X26 and will functions for approximately two hundred shots before it should be replaced. As the battery wears down in the X26 model, the shocking power remains the same. Another addition to the X26 is that of a low powered flashlight. After the unit has been turned on, and the trigger pulled, the weapon operates on a five second cycle regardless of trigger position, and can only be turned off by engaging the safety of the weapon. Additionally, if the TASER X26 trigger is continually depressed, the weapon will continue to cycle uninterrupted. The TASER trigger can therefore be held down for continuous shock or released and pulled again.

TASER recently added the "TASER Cam" which replaced the DPM on the model X26. This audio/visual attachment recorded sound and video in a black & white mpeg4 format every time that the weapon was turned on.

Figure 1: AFIDs (under alternate light source)

The TASER utilizes an Anti-Felon Identification (AFID) tracking system which incorporates serialized microdots, which correspond to cartridge number. This cartridge number can then be traced back to the law enforcement agency and the officer to which the cartridge was issued. When the TASER weapon is fired, twenty to thirty small brightly-colored paper tags are deployed. Despite their bright coloration, AFIDs may be difficult to locate in dark environments. Lounsbury and Thompson (2007) devised a method of locating these disks through the use of an alternate light source (450-480nm), which allows them to fluoresce and are viewable through orange filter glasses.

The cost of the TASER X26 starts at $799.95, while each cartridge is $22.97. The TASER Cam feature costs an additional $399.95. These prices are reflective of costs when purchased by a law enforcement agency, and may be more for individual sale.

STINGER S200

Stinger System makes a number of electric weapons for corrections such as the “Band-It” and the “ICE Shield” which are primarily used for prisoner control and cell extractions. The company recently entered the CED market with their four projectile S400 system, which was quickly replaced by the two projectile S200 model. While it looks slightly larger than a TASER X26, their sizes are almost identical when a cartridge is placed on the TASER X26.

Figure 2: TASER X26 and Stinger S200

On the Stinger S200, the cartridge fits inside the weapon and is removed with an ambidextrous magazine release near the front of the gun. This spring-loaded action forces the cartridge out of the gun. The on/off switch on the Stinger S200 is a cross bolt design (similar to the Remington 870 shotgun safety-switch) and is located above the grip, on the frame of the weapon.

The Stinger has a laser red dot sight that activates when the weapon is turned on. The weapon uses LED lights to provide information to the user, including battery life and a countdown for the length of time left on the weapon's burst of electricity. The electricity cycle on the Stinger S200 lasts for four seconds. The trigger is programmable and can be set to fire only when the trigger is depressed, in two second bursts, or automatically for four seconds.

The Stinger S200 is powered by lithium batteries that are stored in the weapon's grip. The electrical shock used is that of alternating current and the company suggests that this current allows for effective incapacitation even when the probes are close together; however due to fact that all literature on Stinger currently comes from the company itself, this has not been subject to outside review. Due to the fact that a small ballistic primer is used in the cartridge, the weapon is actually considered a firearm by the BATFE. This may limit the sale of the device to the public, based on firearm sale restrictions. Consequently, it may be illegal for the public to carry the Stinger device in some places where it would be legal to carry an alternative-firing device due to restrictions on the carrying of firearms.

The cost of the Stinger S200 is $699.00 and each cartridge is $20.00.

RESEARCH DESIGN

This project consisted of three primary phases of testing. The first phase involved exposure testing on a number of willing participants who signed a liability waiver/release of information. Part two involved accuracy testing of the weapons to achieve probe spread. The third phase was comprised of destruction testing to assess if the weapons would experience problems in the field. Weapons and cartridges were subjected to extreme conditions over an extended period of time to identify weaknesses in design and performance.

In order to conduct this assessment, one member of the research team achieved "Instructor" level certifications from both TASER International and Stinger Systems. The rationale for achieving training beyond the typical end-user level provided to most law enforcement officers was to ensure that the research team had as much knowledge available to them as the companies would provide. This also enabled the research team the opportunity to assess the instructional methods of each company, as these may directly influence how their products are deployed. In addition, the manufacturers provided the instructor course attendees with their instructor materials, which contained additional information not readily available.

Training Classes

Stinger and TASER both offer an instructor course and an end-user certification course. The TASER end-user certification course is 4-6 hours in length and the Stinger end-user course is 6-8 hours in length when taken in person. The Stinger end-user certification course is also available online from the Stinger home page, and according to the manufacturer, this online course is available to any person or entity purchasing their product (see www.Stingersytems.com).

Differences were noted between the training provided for each of the weapon systems' instructor certification courses. TASER X26 training was carried out over 2 full 8-hour sessions. Material was presented in an organized fashion utilizing a combination of power point presentations, complete hard copy data and a Compact Disk containing train-the-trainer materials. The second day of the training allowed the participants direct clinical experience, employing knowledge gained from the first day's work. Scenarios included a wide range of common police scenarios with participants assuming multiple roles. Participants in the class were also able to receive deployments from the weapon system including being shot by the tethered probes. At the end of the training, students were evaluated on their absorption of the content presented through written examination.

Stinger training was scheduled to take 8 hours, but actually was completed in about five hours of instructions and demonstrations. The session utilized handout material largely surrounding the design and electrical capabilities of the device, giving lots of information about how Conducted Energy Weapons work. Some of the material was found to be outdated and incomplete, and the instructor advised participants to ignore sections of the handout material where discrepancies were noted. Each class participant received five applications from the Stinger S200 with a combination of drive-stun shots and applications while the wires were attached to the person utilizing alligator clips. The participants fired live Stinger cartridges at a target, but no student was shot with the probes. There was no formal examination or participant evaluation in this training.

QUALITATIVE ANALYSIS

CED Application (Focus Group)

The first testing phase of the project was to apply each of the weapons on a willing pool of applicants after completing a training seminar on both CED systems. Initially, the research team thought to test the weapons on current law enforcement officers but the idea was quickly discarded due to biases that may have already been present in this group. In the Southwest Florida region, every law enforcement agency carries TASER brand weapon systems and thus their officers have been exposed to this CED and would likely already be unduly influenced by their department and the training they had previously received.

For the purpose of this study, fifteen criminal justice undergraduate students volunteered to participate, and received no credit or payment for their participation. None of the students had ever received an application from either weapon. The volunteer group consisted of male students but this session was not restricted in any way and female students were offered the same opportunity to participate. Despite this, no females volunteered to participate in the study. This testing followed the Florida Gulf Coast University Institutional Review Board (IRB) protocols regarding testing on human subjects.

The focus group testing was conducted at a local fire station due to the availability of Emergency Medical Technicians (EMTs). The students were given a training seminar by the certified TASER and Stinger Instructor/Researcher highlighting the use of CEDs in law enforcement, showing videos of their actual deployment, and were allowed to handle and "dry-fire" the weapons prior to experiencing an application of each CED.

All participants were offered numerous chances to withdraw from the testing, and one student chose to not participate after the instructional period was over. All students were ordered not to participate if they had recently consumed any alcohol or controlled substances. Additionally, student volunteers were also ordered to not participate in the "live-fire" portion of the seminar if they had ANY pre-existing health conditions, and one student self-excluded from the testing because of this caveat. All students who volunteered signed liability waivers and expressed a strong desire to be part of the study.

Focus Group Testing Methodology

In order to maintain the anonymity for each CED and to avoid bias, the participants were not told which CED they were being shocked with and the actual CED was kept out of their sight. The researcher, who was certified as an instructor in both systems, administered an application from each CED at a distance of fifteen feet.

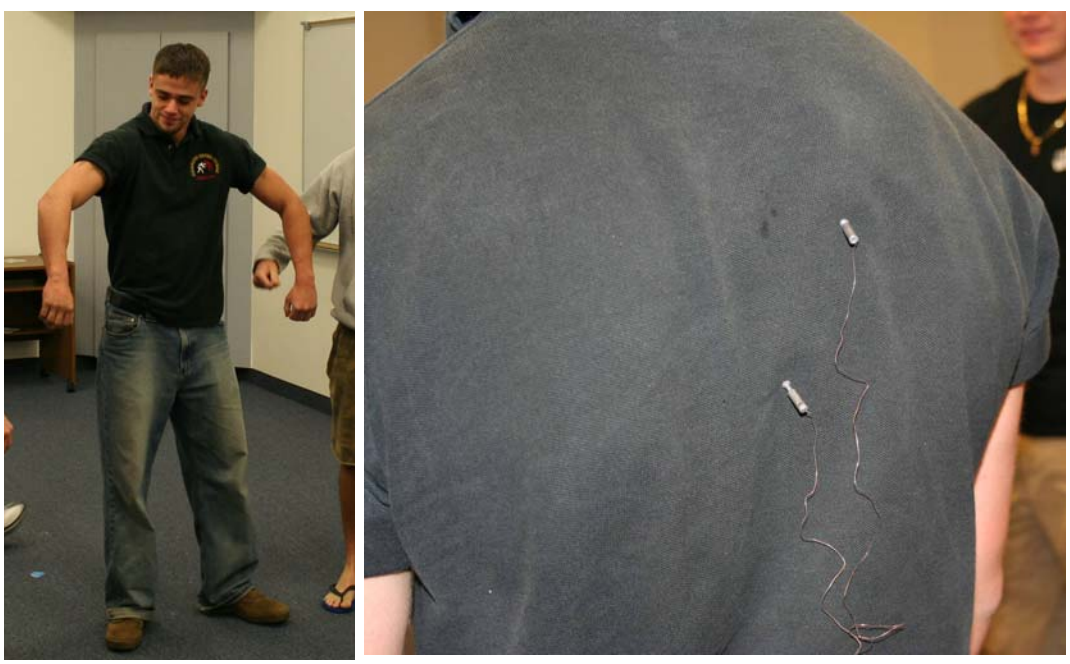
The TASER X26 has a five second run cycle while the Stinger S200 has a four second cycle. In order to minimize reporting and measurement bias, participants were not only blinded to the type of CED being used, but the CED was deployed for only 4 seconds per application regardless of the unit's ability or standard setting to deliver a longer application.

Each participant was held by student volunteers on each side, under the armpit, to keep the participant from falling to the ground. A research assistant ran a video camera, which was focused on the applicants in order to catch their reactions to each application. Additionally, pictures were taken of each subject's back after the application.

For the first test, one student volunteered to be shot with the probes from each CED. The participant, heavily-built and muscular, expressed a strong desire to feel the full effects of each CED and stated that he would refuse to participate in unless he was shot with the actual probes from each CED.

For the first application, a twenty-five foot TASER XP cartridge was shot into the subject's back from a TASER X26 from a distance of approximately ten feet. The probes impacted on his shoulder blade and directly above his waist. The subject's reaction included a tight clenching of the muscles, facial grimace, and clenched teeth. After four seconds, the CED was turned off and the probes were subsequently removed from the subject's back without incident.

Figure 3: Test subject with Probes



After a "cool down" period, the subject volunteer was next shot with a Stinger S200. When fired, the probes from the Stinger S200 impacted much closer together than the TASER X26 probes in the subject's back and the subject screamed and attempted to pull away from the restrainers, managing to twist out of the control of the two individuals holding him. Once the CED was turned off, the subject proclaimed that the effects of this CED (identified as the Stinger S200) were much stronger than that of the other CED

Figure 4: Embedded probes

At this point, however, the Stinger barbs could not be removed according to the instructions issued by Stinger. When proper removal procedure was followed, the barb became disconnected from the probe shaft. The probe removal method for both the TASER and the Stinger follow essentially the same protocol. Probes are removed by spreading the skin around the entry point to make it taut and then quickly jerking on the probe. Such an action leaves a small hole and a minute trace of blood, but little pain or chance of infection as the electricity has cauterized the entrance hole. The Stinger instructor course advocated probe removal in the same fashion as the TASER instructor course. In this case, the barbs could not be removed by attendant EMS staff and the subject had to be transported to the local hospital for removal by a physician.

Due to an ethical concern about doing harm to the additional volunteer subjects involved in this testing, subsequent testing with all other subjects involved the use of alligator clips.

Figure 5: Alligator clips

Alligator clips were attached to clothing of the subjects. Each subject removed any excess clothing down to their baseline of clothing, (an undershirt or a t-shirt) before the probes were attached in order to ensure that there was a minimum amount of electricity lost in the transfer. Initially, one probe was attached to the shoulder area and the other to the lower back. However, it was found that this did not allow a consistent flow of electricity and both probes were then attached to the shoulders for all of the trials involving data collection. The alligator clips were used for both the TASER X26 and the Stinger S200 devices. This placement of the electricity near to, but not imbedded in, the skin simulates real-life police applications where probes land in clothing, but have not penetrated the skin.

Figure 6: Alligator clip placement

All other aspects of the testing protocols remained the same, i.e. not knowing the weapon, spotters to prevent injury from falls, and a video camera recording the CED application. At the completion of each CED application, individual subjects briefly described on camera their feelings and opinion regarding the application of the CED to which they submitted.

After each member of the group was shocked with each CED, and the CED used was randomly changed, they repeated the process with the second CED. In all cases of TASER deployment, the subjects were immediately incapacitated. However, the majority of people had little reaction when hit with the Stinger S200 while this CED was affixed to them via gator clips. In comparison, the individual who experienced a full probe deployment claimed that it was much stronger. However, this is one unique case out of the thirteen. An additional observation made by many of the participants was that the Singer appeared to have a much more localized effect. While many participants reported pain was very severe in a small area when the Stinger S200 was used, pain was felt in a wider distribution and was thus more tolerable with the TASER X26 device. This same effect was noted in the touch stun application (discussed later).

Figure 7: Human subjects testing

When asked to report their opinions on the difference felt between the two types of weapons (blind testing), participants stated about the Stinger:

1) "I didn't feel like doing anything but fall to the ground"
2) "It’s a deep burn...that was awesome"
3) "That one [Stinger] hurts 10X more"…than the TASER (this was from the participant who took the probe hit from the Stinger).

Participants made the following observations about the TASER:

1) "By far, [TASER was] a lot more unpleasant than first weapon [Stinger]"
2) "I was highly motivated to have it stop"
3) "When I said turn it off, I meant it from the bottom of my soul"
4) "That one [TASER] sucks”…clarified to mean TASER was more painful and locks you up.
5) "That one [TASER] was way worse"

Figure 8: Drive stun testing

After all subjects had experienced both the TASER X26 and the Stinger S200 with alligator clips across their back, two subjects volunteered for additional drive stuns from each CED. Each of the two volunteering subjects sat in a chair and each CED was applied in a random fashion to their bare deltoid muscle. Emergency Medical Technicians (EMTs) monitored each subject's heart rate before and after each application of the CED; but did not leave the subjects connected to the EKG while the weapon was deployed. EMTs reported that each subject's heart rate was only slightly elevated both before and after the deployment of the weapon, and they surmised it was due to anxiety. Both subjects reported that a drive stun from the TASER was more incapacitating than one from the Stinger.

Figure 9: Heart rate testing

QUANTITATIVE ANALYSIS

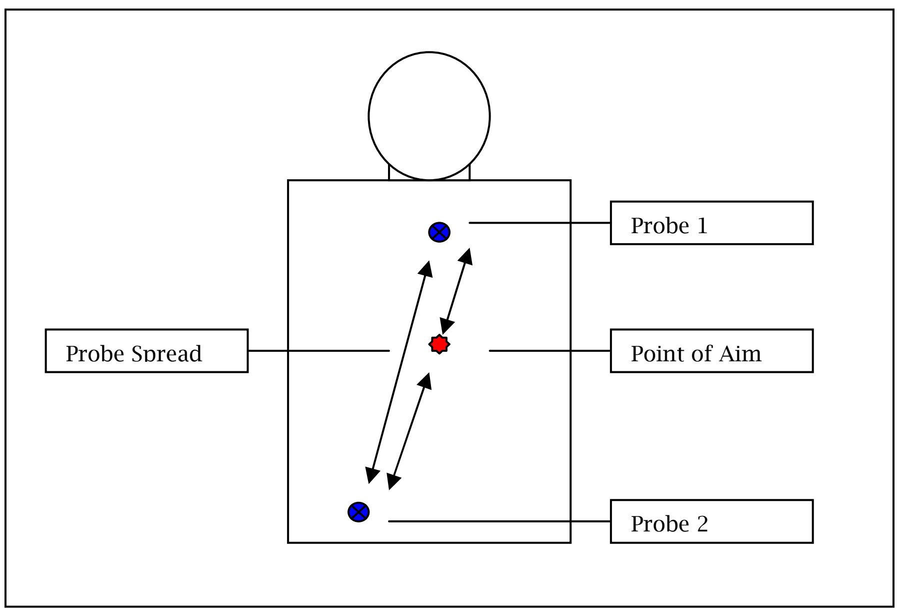
In this phase of the evaluation, the researchers utilized a series of variables determined to be the key variables associated with accuracy. The accuracy variable is considered by the researchers to be the most important variable in terms of functionality of the weapon. This variable was decomposed into several core measures.

The functionality of the TASER is, according to their literature, dependent on at least some distance between the probes and their point of impact and this allows current to flow from probe to probe and through body tissue (TASER X26 Operating Manual, 2006). The result is that the more tissue between the probes, the more the CED is able to incapacitate the subject. Stinger claims that their product has a lower probe spread but does not require much spread to be effective. Clearly, for any effect to take place, the probes in both CEDs need to make contact with the subject in question. Therefore, if one probe fails to make contact with the subject, the incapacitating effect of the electrical current is zero. To examine this concept the researchers developed a fixed firing platform methodology to examine the hit/miss rates of both systems and the actual accuracy of both probes in each firing event.

Accuracy

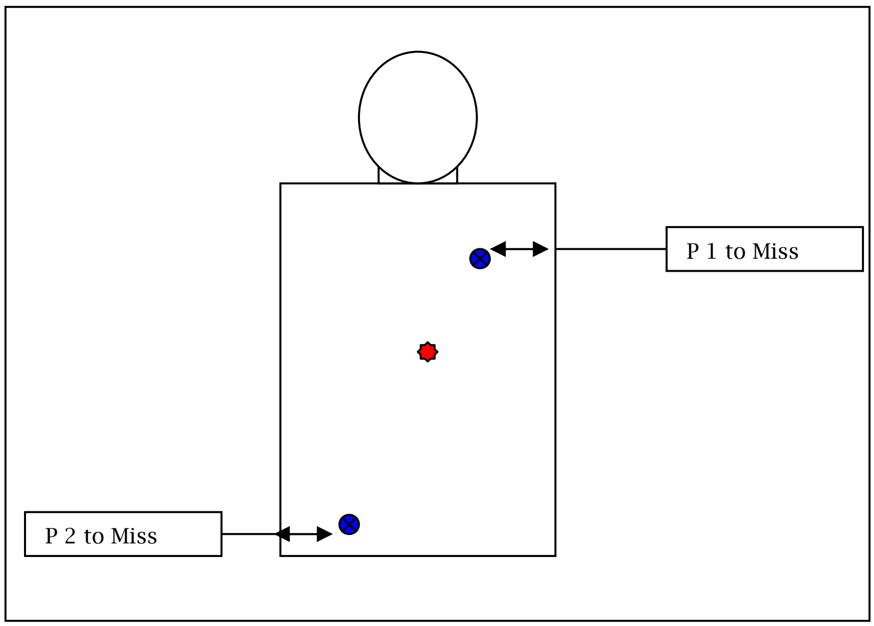
To capture the true accuracy rates of the CEDs under evaluation, the "Probe Accuracy" variable was developed. This variable was calculated by measuring the distance of each probe where it hit the target to the point of aim (laser dot sight). This variable consists of several data points (one for each probe); "Distance from Probe 1 to point of aim," and also Distance from Probe 2 to point of aim." The total distance between the Probes was also measured. These data points are reflected in Figure 10.

Figure 10: Accuracy Based on Probe Spread and Distance from Aim



In addition to the simple measures of probe spread and distance from point of aim, additional data points were captured as "Distance to Miss." This variable is indicative of a measure of how close the probe came to missing the target. This variable was constructed in order to capture an additional dimension of accuracy and the likelihood of a failed deployment. This data point was measured from the point of impact of each probe to the closest point of a miss. This variable is reflected in the Figure 11.

Figure 11: Distance to Nearest Miss



In addition to these measures, the researchers coded an additional measure of accuracy. This measure was coded "Did the Probe Hit the Target". This was coded at a nominal level as a "Yes" or "No."

Lastly, an additional nominal variable was included in the accuracy testing. This variable was "Did the CED Fire"? During the firings of the CEDs malfunctions occurred mainly as failures to fire. This is described in more detail at the conclusion of the report. Obviously, the accuracy of the weapon is affected by these failures to fire and was included in the accuracy analysis.

Accuracy Testing Methodology

Both TASER and Stinger were fired at a target from a fixed platform at distances of 5, 10, 15, and 20-foot intervals. While the TASER is equipped with a lengthier probe tether, which according to TASER allows for shots up to a distance of 25 feet, the Stinger does not and only reaches 22 feet. In order to allow for an unbiased evaluation the two systems were fired at identical distance at which they were both in range of the target.

Target Description

A full-sized plastic/rubber human target was purchased from Law Enforcement Targets, Inc. and is representative of the average human person. The target was clothed in a T-shirt and jeans.

The target remained stationary and the firing platform was moved to simulate firing distances. In the beginning, to maintain accuracy, each weapon was placed in a modified Ransom rest, but the research team soon found this method to be impractical as pressure on the sides of the weapon interfered with the deployment of the cartridges. The testing protocol was revised to use the certified TASER/Stinger instructor shooting each weapon from a rest. Before each shot was taken, the shooter dry-fired the weapon in order to ensure that no “trigger-flinch” was occurring. Trigger flinch is a “jerk” of the weapon associated with the anticipation of firing by the user.

Figure 12: Three-Dimensional Target and Shooting Position

At each predetermined distance, fifty shots from each weapon were fired at the target. Once the weapon had been discharged, the cartridge was removed from the weapon in order to ensure that the research team would not be accidentally shocked while recording measurements. The impact points of the probes were analyzed and their distance from the point of aim was recorded.

However, as the researchers discharged probes at the 3D plastic target, the Stinger probes were unable to penetrate clothing and in many cases would bounce off of the target. This was confirmed by reviewing digital video footage of the firings. Stinger probes were initially coded as misses when they failed to penetrate the target and/or the clothing of the 3D plastic target and generated little data for analysis. As no data could be collected from these firings, the researchers opted for another target option. This secondary option consisted of the “Numb John XT®” target.

Figure 13: “Numb John” Target

The Numb John target is comprised of a softer compound and allowed for the Stinger and TASER probes to both penetrate and be fairly and equally measured. Even though we fired hundreds of projectiles into this target, we were unable to significantly damage it, making it the suitable method for collecting this type of projectile impact data. Since actual probe insertions were under represented for the Stinger device in the first round of deployments, a change to numb John mannequin was carried out in order to be able to compare actual imbedded probe distances for both devices. This was done in order to capture representative data points from Stinger, which was under-represented in the first phase of testing. Further, it allows validation or retesting of summary findings as the methodology is simple to replicate.

Data Collection

The data obtained from the firing of the CEDs was recorded into SPSS, the Statistical Package for the Social Sciences (Version 11) that allows for statistical analysis and the creation of data charts and other outputs.

To measure the data points captured from the probes point of impact, the researchers utilized a standardized measuring methodology consisting of a checklist of data points to be measured. The distances were measured and recorded directly into SPSS. While the data was collected and recorded a supplemental data sheet was maintained in Microsoft Word, where various idiosyncratic issues were recorded as they occurred. The particular issue captured at this time was easily identifiable to a particular distance and CED as it could be cross-referenced by its shot number.

Issues in Data Collection

In the first phase of data collection, the Stinger system repeatedly malfunctioned and the cartridges failed to be discharged so as to strike the target. This prompted the researchers to immediately create a new variable "Cartridge Failed to Deploy." This data point was analyzed at the completion of the project and the following output was developed. The following table reflects the overall weapon "Cartridge Failed to Deploy" variable along with other variables that are discussed in this section.

Table 1: Weapon Malfunctions

	FTD	DF	PB	WB	AD	CD	CI	SU	BP	CE
Stinger:	39	12	2	12	0	5	2	1	0	1
New Stinger:	2	2	2	4	0	4	2	1	0	1
TASER:	2	0	1	4	1	0	1	0	1	0

Legend
FTD = Failed to Deploy
DF = Delayed Fire
PB = Probe Bounced off Target
WB = Wire Broke
AD = Accidental Discharge
CD = Cartridge Dislodged
CI = Collateral Impacts/Shrapnel
SU = Shocked User (shooter shocked through weapon)
BP = Battery Problem
CE = Cartridge Exploded

With the exception of two cartridges that did not deploy properly, all of the TASER cartridges behaved as advertised and as expected. The probe spread was predictable and the weapon was consistent in its operation. The Stinger S200, however, exhibited little consistency.

The probes from the Stinger, when they successfully fired, exhibited idiosyncratic flight behavior. At times, the Stinger S200 probes would land close together, while at other times they would be spread far apart, irrelevant of the distance from the weapon to the target. In addition to the erratic spread of the probes, the probes tended to fly in an untrue linear manner and did not penetrate the target as would often hit the target sideways. Evidence of this was when the barbs bounced off the target and flew back towards the researchers.

Figure 14: Stinger probe inconsistency

When the Stinger was fired at close distances, the probes became stuck in the target. As was the case with our initial volunteer tester, almost every barb broke off in the plastic of the dummy target. An additional observation, however, was the malfunction rate on the Stinger weapon, which was measured, for the initial equipment, at 47.35%. Many times the cartridge simply would not fire, despite the weapon running on a full four-second cycle. The trigger was depressed, the lights showed the cycle time and the researchers could hear the electricity cycling in the weapon, but the cartridge would not ignite. The protocol for that occurrence was to carefully remove the cartridge from the weapon and turn it around so the contact points were switched and insert it into an alternate Stinger S200. The cartridge was then given a second chance to fire. If the cartridge did not fire the second time, it was held at waist level and ejected from the weapon. In most cases, the cartridge would break open upon hitting the ground.

After the researchers contacted Stinger about this issue, we received replacement weapons and cartridges. The performance of the Stinger products was much improved after new hardware was received, and the researchers decided to conduct separate analysis of the original Stinger equipment as well as the new Stinger weapons and cartridges. The failure to fire rate on the new Stinger cartridges dropped to only two out of eighty-four, or 2%.

An additional type of Stinger cartridge malfunction was observed when the weapon would be in the middle of its firing cycle and then the cartridge would deploy. The lag in deployment ranged from an instant deployment of the probes to the cartridge not deploying until the last second of the weapon's cycle.

Figure 15: Stinger Shrapnel

Further problems existed in that the Stinger cartridges would also discharge little pieces of plastic and metal that could best be described as "shrapnel". This was noted numerous times in testing as these items constantly struck the research team. These items were randomly dispersed and would sometimes fly out at nearly a 90-degree angle to the weapon, striking people next to the person deploying the Stinger S200.

Figure 16: Stinger Cross-Bolt Safety

Analysis of Weapon Systems Malfunctions

While those around the shooter experienced safety issues, the person deploying the weapon also had safety concerns with the Stinger

S200. When the cartridge did not deploy properly, the weapon would often lightly shock the shooter when they touched the cross-bolt safety. The length of this shock ranged for a brief "bite" of electricity to one tester receiving a three second shock during a demonstration of the weapon. Shocks occurred twice with the Stinger S200 system, once with the original cartridges, and once with the replacement cartridges.

Failure to Fire Malfunction

This type of malfunction tends to erode both the officer's confidence in the weapon and any deterrent effect on the suspect. TASER cartridges failed to fire in only two cases, in comparison with Stinger's thirty-nine malfunctions with the original Stinger weapon. A visible trend in Stinger cartridge malfunctions emerged each time the weapon was tested. Failure-to-fire malfunctions appeared to cluster within specific boxes of cartridges, indicating a possible problem in quality control. Cartridges which were apparently reviewed by quality control were marked with permanent marker, while others did not have this mark. Most of the malfunctioning cartridges did not have this mark on them.

This variable, while coded as "Weapon Fired," is actually indicative of whether the CED' cartridge functioned and deployed appropriately. It must be stated that the CEDs always "fired" and a cycle of electricity either 4 or 5 seconds long discharged. However despite this, in many of the Stinger test firing cases, the weapon fired, but the cartridge did not deploy.

Figure 17: Stinger Possible Quality Control Mark

The TASER CED fired 214 times out of the 216 times that it was utilized in the data collection. The Stinger CED during the initial phase of data collection, fired 161 times out of 200 times, this effectively calculates to a 19.5% failure to fire rate for Stinger. During this phase the TASER failed to fire 0.9% of the time. The new Stinger variable accounted for a newer batch of cartridges and these had a failure rate of 2.4%.

These failure rates were distributed across the distance intervals at which each CED was fired. Thus, when examining the other variables under review, readers should consider that an unequal number of firings are represented at each distance as a result of the failure to fire rates.

Table 2: Reliability of CED (Failure to Fire)

Count

		Weapon fired		
		No	Yes	Total
Weapon	TASER	2	214	216
	Stinger	39	161	200
	New Stinger	2	82	84
Total		43	457	500

Delayed Fire

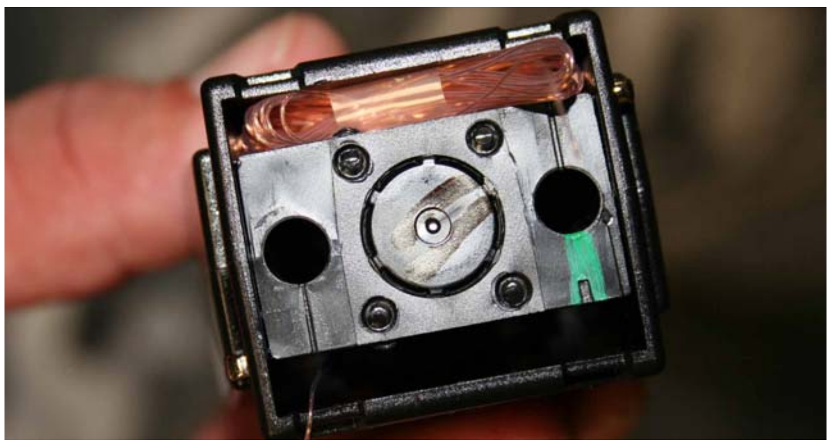
This malfunction occurs when the trigger is depressed, the weapon cycles, but the cartridge does not fire immediately. This malfunction was not observed in any of the TASER X26 tests, but sporadically was found in Stinger S200 tests. This occurred twelve times in the original supply of Stinger cartridges, but only twice in the replacement cartridges.

In some cases, the weapon cycled for three seconds before discharging the probes. In an actual deployment, the suspect would only receive a one second charge before it automatically shut down and would, in an actual field use of the device, likely require the officer to depress the trigger a second time.

Probe Bounced Off Target

As stated previously in this report, there was a problem with probe penetration that was identified in the initial stages of testing. It was unclear if this was a problem with the probe performance or the thickness of the target dummy exterior. This issue was resolved with the substitution of a different target dummy that both the Stinger and TASER CED probes were able to penetrate. TASER probes bounced off the target in one case, while it occurred to Stinger probes twice in both the original and new cartridges.

Figure 18: TASER Probe Malfunction



Probe Wire Broke

Although probe wires are often broken during confrontations with suspects, this study examined if probe wire broke during the initial firing of the weapon. This malfunction was observed during this analysis for both weapon systems. In four cases, TASER X26 cartridges malfunctioned and fired the probes but the wire failed to deploy and broke. Shown in figure 18, the wire is clearly still spooled in the cartridge, while the probe is missing. The Stinger S200's cartridges had three times as many malfunctions of this type (n = 12) in the original supply of cartridges, while the new cartridges performed considerably better with only four wire breaks.

Accidental Discharges

In this study, the researchers discharged over six hundred cartridges between the two CED weapon systems. Safety protocols were established prior to testing, which treated all CEDs as a firearm, regardless of being loaded. Despite these safety protocols, a single accidental discharge occurred with a TASER. The weapon had malfunctioned several times due to a DPM (battery) not seating properly. As a result, the weapon repeatedly went through its systems diagnostics routine.

The weapon was removed from its firing position and the battery was removed. However, the cartridge was left on the weapon. When a new DPM was inserted, the TASER instantly fired into the floor without the trigger being depressed. It was also found that the safety had been bumped to a halfway position between safe and fire. The cartridge was left in place and the DPM was removed and re-inserted a second time to duplicate the conditions and the weapon again discharged. Initially, it was thought that this was a malfunction or a freak occurrence. However, the TASER "Instructor Materials" clearly warns against replacing the DPM while the weapon is loaded, "Warning: Ensure that no live cartridges are loaded prior to running this drill" (p.114). Consequently, we viewed this as an operator error but noteworthy in this report, as TASER's materials do not address this issue beyond this single sentence warning.

Cartridge Dislodged

This type of malfunction occurred when the cartridge released itself from the weapon upon firing. In some cases, the cartridge would simply fall off, while in others it would be propelled downrange toward the target. This occurred five times with the original Stinger S200 cartridges and four times with the new Stinger S200cartridges. No malfunctions of this type were noted with TASER X26 cartridges.

Collateral Impacts

This issue occurred when the weapon user was struck with some projectile after firing. As stated previously, Stinger cartridges produced a wide range of plastic and metal shrapnel that flew in all directions. It is believed that this shrapnel impacted the target and bounced back toward the shooter at relatively high speed. This did not occur with TASER cartridges, with the exception of a single TASER probe that separated from its wire tether bounced off the target and struck the shooter without puncturing the skin.

Shocked User

In addition to the electric shock received from activating the safety while the Stinger is in a firing cycle, there were two events where the shooter was shocked through the grip during testing. Unlike a short, low intensity “bite”, which occurs when officers briefly touch an area that is charged from a CED deployment, this shock was the equivalent of a drive stun and equally incapacitating. It is unclear why this occurs with the Stinger weapons, but it occurred with two different weapons that were from two different shipments. No problems of this type were noted with TASER weapons.

Battery Problem

No battery problems were noted with any of the Stinger weapons. A single battery (DPM) failed to seat properly in the TASER X26, which caused it to repeatedly restart its diagnostic sequence. This DPM was replaced and no further problems were encountered.

Cartridge Exploded

In two cases, the Stinger cartridge exploded when the weapon was fired. Beyond the shrapnel that was produced from the Stinger, these cartridges dislodged their entire firing mechanism. As shown in Figure 19, the center of the cartridge which houses the primers and probes shows considerable scoring from the blast. The center of the cartridge was propelled downrange (15 feet) and impacted the target. It is unclear what caused this malfunction.

Figure 19: Stinger Cartridge Explosion

Accuracy Analysis

In examining the accuracy of the CEDs, the researchers have structured this section based upon the premise that if both probes make contact with a subject then the CED will deploy an incapacitating charge into the subject. This hit or miss approach guided the researchers to develop a macro approach to the question of "Did the CED deploy accurately enough to be effective?" Both CEDs were tested at intervals of 5 feet, 10 feet, 15 feet, and 20 feet.

Tables 2 and 3, Probe 1 and Probe 2 (Hit or Miss), reflect a simple analysis of whether the Probe(s) were accurate enough to make contact with the target at the various distances. In determining whether the TASER and Stinger would be effective, it becomes necessary for both probes to make contact with the target. In this research design, the point of impact of each probe was captured as "Did Probe 1 Hit", a "yes" indicates the probe made contact and stuck in the targets exterior clothing or penetrated the dummy. The value of zero in Table 3 indicates no misses. A cartridge that failed to fire was coded as a miss for this performance measure.

TASER: Table 3 shows that TASER X26 Probe 1 was 100% accurate, at hitting the target up to 15 feet of distance. At 15 feet of distance, misses began to occur and TASER X26 Probe 1 missed 3 out of 54 times (5.6%). This miss-rate increases as distance increases and holds true at 20 feet of distance where Probe 1 missed 25 out of 57 times (78%). In an aggregate calculation, TASER's Probe 1 failed to hit the target in 28 out of 216 deployments for a failure rate of 13%. However this failure rate needs to be considered in light of the misses occurring almost exclusively at the 20-foot distance interval.

Table 3: Probe 1 (Hit or Miss)

Count

Weapon			Distance to target 5 ft	10 ft	15 ft	20 ft	Total
TASER	Did probe one hit?	No	0	0	3	25	28
		Yes	52	50	54	32	188
	Total		52	50	57	57	216
Stinger	Did probe one hit?	No	10	14	9	15	48
		Yes	40	36	41	35	152
	Total		50	50	50	50	200
New Stinger	Did probe one hit?	No	2	1	3	5	11
		Yes	27	26	19	1	73
	Total		29	27	22	6	84

Stinger: Probe 1 was constantly less accurate than TASER X26 Probe 1. In this performance testing at 5-feet, Probe 1 missed 20% of the time. At 10-feet, Probe 1 missed 28% of the time, at 15-feet Probe 1 missed 18% of the time and at 20 feet Probe 1 missed 30% of the time. (Note: Some cartridges failed to fire/discharge at all). Overall, Stingers Probe 1 failed to fire or hit the target 48 out of 200 deployments/attempted deployments (24%). This failure rate is fairly evenly distributed across the various distance intervals.

New Stinger: In the newer "batch" of Stinger cartridges, supplied by Stinger, the performance rates were much improved. At 5-feet, 6.9% failed to deploy or missed (n = 29), at 10 feet 3.7% failed (n = 27), at 15 feet, 13.6% failed (n = 22) and at 20 feet, 13.1% failed (n = 11). Overall the performance of the new "batch" of Stinger cartridges was much improved over the original batch. This batch appeared to be of improved quality and reliability. Overall, this batch of cartridges had a failure rate of 13.3%, which was relatively evenly distributed, across the various distance intervals. However, these cartridges only represent 84 deployments and are a small number of any reliable extrapolations.

For either the TASER or Stinger CED to be effective, as mentioned earlier, it is important that both probes make contact with the subjects' clothing or their skin. This being the case, the researchers examined whether the second probe (Probe 2) made contact. As with the first probe, in some cases the Stinger and TASER cartridge failed to deploy despite the weapon cycling through a 4 or 5 second shooting cycle. This failure to deploy is detailed more in this report in the section on cartridges and CED malfunctions.

TASER: At a 5-foot distance, TASER's X26 Probe 2 missed the target 2 out of 52 times (3.8%), at 10 feet there were no misses, at 15 feet 7 shots out of 57 were misses (12.3%), and at 20 feet, 46 deployments of Probe 2 were misses for a total of 80.7%. Overall, 55 out of 216 TASER X26 probes missed the target (predominant issue) for a missed/failure rate of 25.5%. As with Probe 1, the majority of the probe misses were at the longer distances, with the distance interval of 20 feet representing almost all of the TASER's X26 Probe 2 failures.

Table 4: Probe 2 (Hit or Miss)

Count

Weapon			Distance to target 5 ft	10 ft	15 ft	20 ft	Total
TASER	Did probe two hit?	No	2	0	7	46	55
		Yes	50	50	50	11	161
	Total		52	50	57	57	216
Stinger	Did probe two hit?	No	16	17	12	18	63
		Yes	34	33	38	32	137
	Total		50	50	50	50	200
New Stinger	Did probe two hit?	No	3	2	3	4	12
		Yes	26	25	19	2	72
	Total		29	27	22	6	84

Stinger: At 5 feet, 16 out of 50 Stinger S200 Probes failed to hit or fire when deployed (32%), while at the 10 foot distance interval the

Stinger S200 Probes failed to hit or fire 17 times out of 50 shots (34% failure rate). At the 15-foot range interval, 12 Probes out of 50 failed to fire or hit the target (24%). Lastly, at 20 feet of distance 18 out of 50 cartridges failed to fire or hit the target for a 36% failure rate. Overall, Stinger S200 failed to hit the target or deploy (predominantly failure to deploy) for an overall failure rate of 31.5%. Stinger S200 Probe 2 failures were relatively evenly distributed across the various distance intervals.

New Stinger: As mentioned earlier, because of the high failure rates of the first batch of Stinger cartridges, new cartridges were provided by Stinger. This batch, referred to as "new Stinger" in the data code sheet, reflects the newer cartridges and allowed for comparison as such. This batch of cartridges performed better and failure rates were significantly reduced. At the 5 feet of distance interval, 3 out of 29 failed (10.3%). At 10 feet, 2 Probes out of 27 failed to hit the target or failed to fire (7.4%), at 15 feet 3 probes out of 22 failed to hit or fire (1.4%), and at 20 feet 4 out of 6 failed to hit or fire (66.7%).

Overall, the newer batch had 12 out of the 84 cartridges that missed the target or failed to fire for an overall failure rate of 14.3%. A caveat must be added here, that the N of this sample is much smaller than the other groups (N=84). As with Stinger S200 Probe 1 and Probe 2, this batch of probes also failed to hit the target or fire relatively consistently at all distance intervals.

A review of Table 5 shows the distances of Probe 1 and Probe 2 from the point of aim (from the red dot site on each CED). The data reported here is the mean data (average of all the shots at the distance interval described) and the number of shots fired (represented by N).

5-Foot Distance Testing

Taser: At the 5-foot distance interval, TASER's X26 Probe 1 was a mean distance of 2.8 inches from the point of aim. The red dot sight is the point of aim reference point for these measures. The TASER X26 second Probe was an average of 7.0 inches from the point of aim. This probe (probe 2) is generally 7.0 inches lower (down) from the point of aim, as the TASER X26 cartridges fire the probe at an angle (stated as 8°) (X26 Instructor Materials, Taser International 2004).

This downward angle is important and is discussed later in this report where the researchers calculate regression lines for the probes and spread rates at the other distances. These means are based sample values of N= 52 for Probe 1 deployments and N-50 for Probe 2[1].

Stinger: At the 5-foot distance interval, Stingers S200 Probe 1 was a mean distance of 2.6 inches from the point of aim. The CED's standard red-dot sight is the point of aim reference point for these measures. The Stinger second probe was an average of 2.5 inches from the point of aim. This probe (probe 2) was generally 2.4 inches lower (down) from the

[1] Only 50 data points were captured here, compared to 52 for Probe 1 as in the two cases the Probes failed to hit the target or did not penetrate the clothing or target to allow for data point capture.

point of aim, as the Stinger S200 cartridge's fire the probe at an angle (stated as 5.5°) (Stinger Instructor Course Materials, 2006). This downward angle is important and is discussed later in this report where the researchers calculate regression lines for the probes and spread rates at the other distances.

New Stinger: As identified in the first round of testing, the Stinger S200 Cartridges failed to fire in much of the testing. As a result, the researchers contacted Stinger and requested additional cartridges to be delivered to compensate for the defective ones. This newer "batch" of cartridges was coded differently to allow for comparison with original shipment of cartridges. At the 5-foot distance, the new Stinger Probe 1 had 3.4 inches of deviation from POA and Probe 2 had 2.9 inches of distance from point of aim deviation.

10 Foot Distance Testing

TASER: At the 10-foot distance interval TASER Probe 1 landed a mean distance of 3.6 inches from POA and Probe 2 landed 15.5 inches from POA (n = 50 for both).

Stinger: The Stinger CED had a mean score of 3.5 inches for Probe 1 (n = 37) and 5.5 inches for Probe 2 (n = 34) at 10 feet of testing.

New Stinger: The new cartridges had relatively similar means scores; Probe 1 (n = 26, 5.6 inches) and Probe 2 (6.2 inches, n = 25).

Table 5: Probe 1 & Probe 2; Distance from Point of Aim

Distance to target	Weapon		Distance from probe 1 to POA	Distance from probe 2 to POA
5 ft	TASER	Mean	2.8279	6.9800
		N	52	50
		Std. Deviation	.80241	.50679
	Stinger	Mean	2.5600	2.4074
		N	40	34
		Std. Deviation	1.02151	1.36942
	New Stinger	Mean	3.4259	2.8662
		N	27	26
		Std. Deviation	1.12783	2.13691
	Total	Mean	2.8735	4.5943
		N	119	110
		Std. Deviation	1.00374	2.55844
10 ft	TASER	Mean	3.5700	15.4890
		N	50	50
		Std. Deviation	.84781	.92219
	Stinger	Mean	3.4743	5.4647
		N	37	34
		Std. Deviation	1.70190	1.86277
	New Stinger	Mean	5.6019	6.1860
		N	26	25
		Std. Deviation	2.92221	2.95005
	Total	Mean	4.0062	10.2284
		N	113	109
		Std. Deviation	1.98017	5.20756
15 ft	TASER	Mean	2.8944	25.0090
		N	54	50
		Std. Deviation	1.38219	1.43661
	Stinger	Mean	5.3774	9.4581
		N	42	37
		Std. Deviation	2.77658	3.11235
	New Stinger	Mean	5.2737	13.5421
		N	19	19
		Std. Deviation	2.53083	4.97531
	Total	Mean	4.1943	17.5255
		N	115	106
		Std. Deviation	2.48644	7.81031
20 ft	TASER	Mean	4.2464	36.0186
		N	56	51
		Std. Deviation	1.97691	4.07637
	Stinger	Mean	9.7865	16.2589
		N	37	35
		Std. Deviation	5.89776	4.39789
	New Stinger	Mean		24.8667
		N		3
		Std. Deviation		2.09841
	Total	Mean	6.4505	27.8720
		N	93	89
		Std. Deviation	4.83530	10.46063

15 Foot Distance Testing

TASER: At the 15-foot distance interval TASER Probe 1 (N=54) landed a mean distance of 2.9 inches from POA and Probe 2 landed 25 inches from POA (n = 50).

Stinger: The Stinger CED had a mean score of 5.4 inches for Probe 1 (n = 42) and 9.5 inches for Probe 2 (n = 37) at 15 feet of testing.

New Stinger: The new cartridges had relatively similar means scores; Probe 1 (5.3 inches, n = 19) and Probe 2 (13.5 inches, n = 19).

20 Foot Distance Testing

TASER: At the 20-foot distance interval TASER Probe 1 (n = 56) landed a mean distance of 4.2 inches from POA and Probe 2 landed 36 inches from POA (n = 51).

Stinger: The Stinger CED had a mean score of 9.8 inches for Probe 1 (n = 37) and 16.3 inches for Probe 2 (n = 35) at 20 feet distance testing.

New Stinger: At 20 feet testing Probe 1 failed to hit the target. While these cartridges did in fact fire, the probes failed to hit the target as they were unable to fully deploy due to entanglements of the wire tethers. Probe 2 had a mean distance of 13.5 inches (n = 19). After numerous occurrences, we named this issue the “bungee effect”, as the probes were snapped back as if on a bungee cord.

In comparing the number of cartridges fired for each CED, the researchers initially attempted to fire an equal number of shots at each distance interval for each CED. However in the first round of testing the Stinger malfunctioned and failed to fire so many times that an equal number of shots and data collection point became unfeasible. Thus, the researchers were forced to fire a disproportionate number of Stinger cartridges in order to balance the data for each CED in the various distance intervals. These malfunctions and failures to fire are examined in more detail in the section of Weapons Malfunctions.

Figure 20: Stinger wire entanglement

Unequal Samples for Comparison

Probe Spread

Another measure of relative accuracy and effectiveness of the CED is based upon whether both probes make contact with the subject. As such, the distance between Probe 1 and Probe 2 has been captured and reported in this table. This table reports the mean scores of the distances between the probes and has been decomposed to reflect this "spread" at the various distance intervals.

5-Foot: Probe-Spread Testing

At the 5-foot distance interval, the TASER probe spread from Probe 1 to 2 was an average of 9.4 inches (n = 50). The Stinger has a smaller probe spread of 4.0 inches (n = 34). The New Stinger Cartridges were relatively similar to the original batch of Stinger cartridges and had a mean spread of 4.8 inches (n = 25).

10-Foot: Probe-Spread Testing

At the 10-foot distance interval the TASER probe spread from Probe 1 to 2 was an average of 18.5 inches (n = 50). The Stinger has a smaller probe spread of 7.5 inches (n = 34). The New Stinger Cartridges were relatively similar to the original batch of Stinger cartridges and had a mean spread of 10.2 inches (n = 25).

15-Foot: Probe-Spread Testing

At the 15-foot distance interval the TASER probe spread from Probe 1 to 2 was an average of 26 inches (n = 50). The Stinger has a smaller probe spread of 11.7 inches (n = 37). The New Stinger Cartridges had a mean probe spread of 14.5 inches (n = 17).

20-Foot: Probe-Spread Testing

At the 20-foot distance interval the TASER probe spread from Probe 1 to 2 was an average of 35 inches (n = 50). The Stinger has a smaller probe spread of 14.1 inches (n = 32). The New Stinger Cartridges had a mean probe spread of 14.5 inches (n = 17).

Table 6: Probe Spread (Measured from Probe 1 to Probe 2)

Projectile spread

Distance to target	Weapon	Mean	N	Std. Deviation
5 ft	TASER	9.4200	50	.65745
	Stinger	4.0412	34	1.40710
	New Stinger	4.7620	25	1.60502
	Total	6.6739	109	2.80945
10 ft	TASER	18.4540	50	1.45630
	Stinger	7.4588	34	2.32488
	New Stinger	10.2400	25	4.07469
	Total	13.1404	109	5.61110
15 ft	TASER	25.9250	50	3.57206
	Stinger	11.6757	37	3.34445
	New Stinger	14.4588	17	3.78522
	Total	18.9813	104	7.62619
20 ft	TASER	34.9240	50	4.59115
	Stinger	14.0797	32	4.96379
	New Stinger			
	Total	26.7896	82	11.26254
Total	TASER	22.1808	200	9.88373
	Stinger	9.2960	137	5.00412
	New Stinger	9.2664	67	5.04349
	Total	15.6697	404	10.12524

Distance to Potential Miss

Another important measure of relative accuracy of the CED under evaluation is a measure of how much distance the Probe 1 and Probe 2 had (described as leeway or accuracy error) before it would have missed the target. At issue here again, is the concept that both probes need to make contact with the subject in order for the TASER and/or Stinger CED to be effective

To collect this data point, as referenced in Figure 11, the researchers measured the closet or nearest distance from the probes point of impact to the nearest point where the probe/s would have failed to make contact with the target. In this testing the outer garments of the targets were coded as a hit largely as the literature from Stinger and TASER indicate electric arcs occur from their probes to the person thus still making them effective.

Table 7 reports the mean scores of Probe 1 and Probe 2 for the TASER, Stinger and the new Stinger cartridges. The mean scores are decomposed to the distance interval under evaluation.

5-Foot Distance Interval (Nearest Potential Miss)

Taser: At 5-feet of distance, the TASER's Probe 1 had a mean score of 7.1 inches (n = 52) of leeway before a miss would have occurred. Probe 2 averaged 7.2 inches (n = 50) of leeway until a miss. Two cases occurred where Probe 2 missed the target and as such no data was captured.

Stinger: At 5-feet of distance, the Stinger Probe 1 averaged 7.2 inches of leeway (n = 40) and Probe 2 averaged 7.5 inches (n = 34) of leeway before its nearest potential miss.

New Stinger: The new Stinger cartridges Probe averaged a mean nearest miss score of 7.2 inches (n = 27) and Probe 2 averaged a nearest miss score of 9 inches (n = 26).

10-Foot Distance Interval (Nearest Potential Miss)

Taser: At 10-feet of distance, the TASER's Probe 1 had a mean score of 6.1 inches (n = 50) of leeway before a miss would have occurred. Probe 2 averaged 6.6 inches (n = 50) of leeway until a miss could have potentially occurred.

Stinger: At 10-feet of distance, the Stinger Probe 1 averaged 6.2 inches of leeway (n = 37) and Probe 2 averaged 6.2 inches (n = 34) of leeway before its nearest potential miss.

New Stinger: The new Stinger cartridges Probe averaged a mean nearest miss score of 5.5 inches (n = 26) and Probe 2 averaged a nearest miss score of 7.6 inches (n = 25).

Table 7: Distance to Probe 1 and Probe 2 Miss

Distance to target	Weapon		Distance to miss probe 1	Distance to miss probe 2
5 ft	TASER	Mean	7.0510	7.1720
		N	52	50
		Std. Deviation	.89149	1.95334
	Stinger	Mean	7.1813	7.4735
		N	40	34
		Std. Deviation	1.17417	1.94201
	New Stinger	Mean	7.1296	9.0385
		N	27	26
		Std. Deviation	1.12858	1.17408
	Total	Mean	7.1126	7.7064
		N	119	110
		Std. Deviation	1.04074	1.93504
10 ft	TASER	Mean	6.1310	6.5890
		N	50	50
		Std. Deviation	1.25095	2.14158
	Stinger	Mean	6.1689	6.2000
		N	37	34
		Std. Deviation	2.05597	1.93332
	New Stinger	Mean	5.5481	7.5540
		N	26	25
		Std. Deviation	2.25142	2.27119
	Total	Mean	6.0093	6.6890
		N	113	109
		Std. Deviation	1.79977	2.14996
15 ft	TASER	Mean	6.4028	3.0520
		N	54	50
		Std. Deviation	1.91352	1.81538
	Stinger	Mean	5.4805	6.0730
		N	41	37
		Std. Deviation	2.23668	2.22038
	New Stinger	Mean	7.2316	6.0000
		N	19	19
		Std. Deviation	4.14287	2.36579
	Total	Mean	6.2092	4.6349
		N	114	106
		Std. Deviation	2.57071	2.53906
20 ft	TASER	Mean	5.7672	1.3636
		N	32	11
		Std. Deviation	1.96155	.99426
	Stinger	Mean	5.0191	4.6385
		N	34	33
		Std. Deviation	2.81839	2.31242
	New Stinger	Mean		3.5167
		N		3
		Std. Deviation		.92241
	Total	Mean	5.3818	3.8004
		N	66	47
		Std. Deviation	2.45148	2.42915

15-Foot Distance Interval (Nearest Potential Miss)

Taser: At 15-feet of distance, the TASER's Probe 1 had a mean score of 6.4 inches (n = 54) of leeway before a miss would have occurred. Probe 2 averaged 3 inches (n = 50) of leeway until a miss could have potentially occurred.

Stinger: At 15-feet of distance, the Stinger Probe 1 averaged 5.5 inches of leeway (n = 41) and Probe 2 averaged 6.0 inches (n = 37) of leeway before its nearest potential miss.

New Stinger: The new Stinger cartridges Probe averaged a mean nearest miss score of 7.2 inches (n = 19) and Probe 2 averaged a nearest miss score of 6.0 inches (n = 19).

20-Foot Distance Interval (Nearest Potential Miss)

Taser: At 20-feet of distance, the TASER's Probe 1 had a mean score of 5.8 inches (n = 32) of leeway before a miss would have occurred. Probe 2 averaged 1.4 inches (n = 11) of leeway until a miss could have potentially occurred. As indicated earlier in this report, the accuracy of the TASER reduces dramatically at the 20-foot distance. This is reflected here in the near miss data, which shows the number of cases (N) as being relatively low. The missing cases are indicative of no data being collected because of misses.

Stinger: At 20-feet of distance, the Stinger Probe 1 averaged 5.0 inches of leeway (n = 34) and Probe 2 averaged 4.6 inches (N = 33) of leeway before its nearest potential miss.

New Stinger: The new Stinger cartridges Probe 1 failed to hit the target and Probe 2 averaged a nearest miss score of 3.5 inches (n = 3). The number of probes that hit in this case was extremely small. The researchers fired at least 20 cartridges in this testing scenario and only several made contact (at the cost of $20 per cartridge, the researchers ceased to continue to shoot at this distance due to cost considerations and poor performance leading to no data collection). This cost/data collection issue was also present in the initial testing phase wherein a large number of Stinger cartridge malfunctions/failure-to-fire occurred.

Projection of CED Probe Spread

Based upon our analysis of individual weapon and cartridge performance, it was possible to create a projection of probe spread at any distance. A linear regression of probe spread and distance indicated a strong positive significant relationship for TASER (r=.983), Stinger (r=.807) and the new Stinger cartridges(r=.765).

Using the un-standardized beta coefficients in each model, the probe spread can be determined for each foot of distance between suspect and weapon. TASER was found to have a 1.77 inch spread for every foot of distance, in comparison with Stinger's .67in./ft. and the new

Stinger cartridge's .98in. /ft. Using these values, probe spread can be predicted to the length of the TASER's conductive wire (as shown in below Table 11). After these predictions were established, we plotted a prediction line alongside the mean probe spread scores for each CED.

Table 8: Comparison of Projected Probe Spreads with Actual Scores

	TASER Projected	TASER Actual
Five feet	8.85 in	9.42 in
Ten feet	17.70 in	18.45 in
Fifteen feet	26.55 in	25.93 in
Twenty feet	35.40 in	34.92 in
	Stinger Projected	Stinger Actual
Five feet	3.35 in	4.04 in
Ten feet	6.70 in	7.46 in
Fifteen feet	10.05 in	11.68 in
Twenty feet	14.08 in	14.07 in
	New Stinger Projected	New Stinger Actual
Five feet	4.90 in	4.76 in
Ten feet	9.80 in	10.24 in
Fifteen feet	14.70 in	14.46 in
Twenty feet	19.60 in	No data[2]

The data from these projections is shown below in Table 11 for both weapons. It is then possible to determine with a high degree of accuracy the amount of projectile spread at a given distance. However, after fifteen feet, accuracy and performance of both weapons is significantly reduced.

[2] No data collected as new cartridges' probes failed to strike target at this distance.

Table 9: TASER and Stinger Probe Spread by Distance

Report

Distance in feet	TASER spread	Stinger spread	New Stinger spread
1.00	1.77	.67	.98
2.00	3.54	1.34	1.96
3.00	5.31	2.01	2.94
4.00	7.08	2.68	3.92
5.00	8.85	3.35	4.90
6.00	10.62	4.02	5.88
7.00	12.39	4.69	6.86
8.00	14.16	5.36	7.84
9.00	15.93	6.03	8.82
10.00	17.70	6.70	9.80
11.00	19.47	7.37	10.78
12.00	21.24	8.04	11.76
13.00	23.01	8.71	12.74
14.00	24.78	9.38	13.72
15.00	26.55	10.05	14.70
16.00	28.32	10.72	15.78
17.00	30.09	11.39	16.66
18.00	31.86	12.06	17.64
19.00	33.63	12.73	18.62
20.00	35.40	13.40	19.60
21.00	37.17	14.07	20.58
22.00	38.94	14.74	21.56
23.00	40.71	15.41	22.54
24.00	42.48	16.08	23.52
25.00	44.25	16.75	24.50

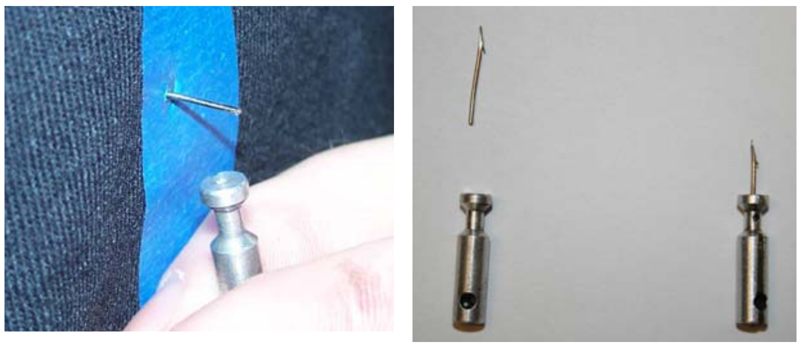
Other Variables Related to Functionality

This section of the report examines the other variables under consideration to include, probe durability, CED reliability, CED durability, tensile strength of the cartridges' wire connections, tests of the elements (humidity, heat, cold and water) and several others.

Probe Broke During Removal

During testing, the researchers became aware of the number of probes that broke during removal from the testing subject and targets.

Figure 21: Probe Break



In addition to capturing images of this, the researchers developed a variable "Did Probe Break" which was used to capture whether the base of the probes separated from the barb which was fixed in the target. Of concern here is whether or not an officer would be able to process a subject into a correctional facility if they required the medical or surgical removal of a barb.

Table 10 reflects a code scheme that captured a probe break as one incident even if both probes broke off. Thus if one or both probes broke during removal the data is coded to be reflected as 1 break in the above table.

Table 10: Probe Separated from Barb During Removal

Count

		Weapon			
		TASER	Stinger	New Stinger	Total
Did probe break?	No	212	107	74	393
	Yes	1	52	4	57
Total		213	159	78	450

During the testing a total of 450 data points were collected regarding the probes and whether they broke off from the barb during removal from the target.

TASER: One TASER probe broke off in the target requiring channel locks to be removed (0.4%).

Stinger: The Stinger probes frequently broke off in the target during testing and their removal. During this testing, 52 Probes out of 159 Stinger cartridges broke off in the testing target (32.8%). This occurred primarily at five and ten foot firing distances.

New Stinger: Out of the new cartridges, a relatively fewer number required extreme measures to remove and only 4 out of the 78, where data was captured, broke off and remained in the target (5%).

Durability Testing

Key to all law enforcement equipment is how well it will survive while in use. The majority of equipment carried on an officer's belt will be subject to a great deal of daily abuse in their course of normal actions. If it cannot withstand the rigors of everyday use and carry, then the equipment is essentially useless as no officer will have faith in it.

Tensile Strength Testing

If the wire on a CED cartridge is easily broken, then it is less likely that a subject will be effectively incapacitated by the shock. At this stage of testing, we chose twenty random cartridges from both TASER and Stinger and measured the tensile strength of the wires connecting the probes to the cartridge. For safety reasons, we used cartridges that had already been discharged as we did not want to open up a cartridge while the firing mechanism was intact.

To measure the number of foot-pounds necessary to break the wire, a trigger pull gauge was utilized as it records the maximum weight placed on it. The wire end with the probe attached was tied to the gauge, held by one tester, and another tester pulled on the cartridge, stretching out the wire and exerting increasing pressure. When the wire snapped, the number of pounds was recorded from the trigger pull gauge. On average, tether strength for both TASER and Stinger were similar. However, there was a great deal of variance within each brand.

Table 11: Tensile Strength of Probe Tethers

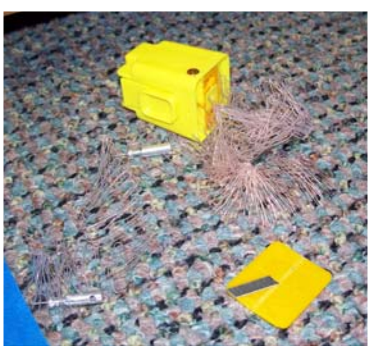
Tension strength

Weapon	N	Mean	Median	Minimum	Maximum	Std. Deviation
TASER	50	25.5760	26.1500	8.50	30.40	3.83127
Stinger	50	25.6460	25.1000	12.70	43.50	6.53553
Total	100	25.6110	25.9000	8.50	43.50	5.32985

Durability Testing (Cartridge Drops)

During accuracy testing, we deliberately dropped a number of cartridges from a height of four feet to determine their survivability. None of the TASER cartridges broke during this test; however, fourteen out of the twenty Stinger cartridges broke upon impact with a carpeted floor. Additionally, a number of Stinger cartridges were broken while still in their shipping container. The blast doors fell off, releasing the wire tether.

Figure 22: Broken Cartridges



Stinger appeared to be addressing this issue by placing a small, clear piece of tape across the blast doors to prevent this type of malfunction. However, at least one new malfunction was noted when the blast doors failed to separate when the weapon was fired.

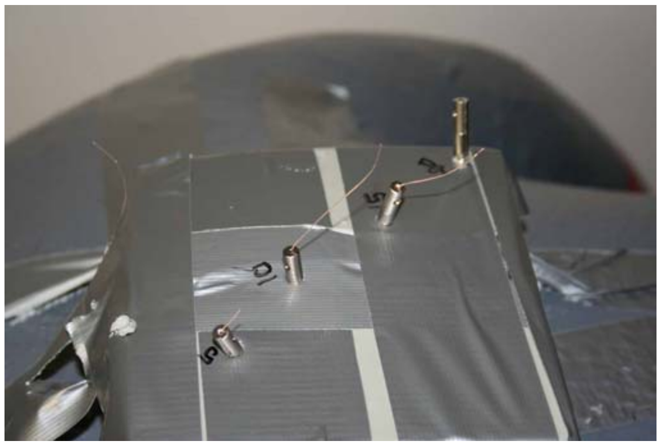
Figure 23: Blast door malfunction

Penetration Testing

In an attempt to standardize a testing methodology for the penetration of the probes from each CED, a series of cartridges were fired at ballistic clay. Ballistic clay (specifically, Roma Plastelina #1) was utilized and the CEDS were fired into the clay at all of the distance intervals.

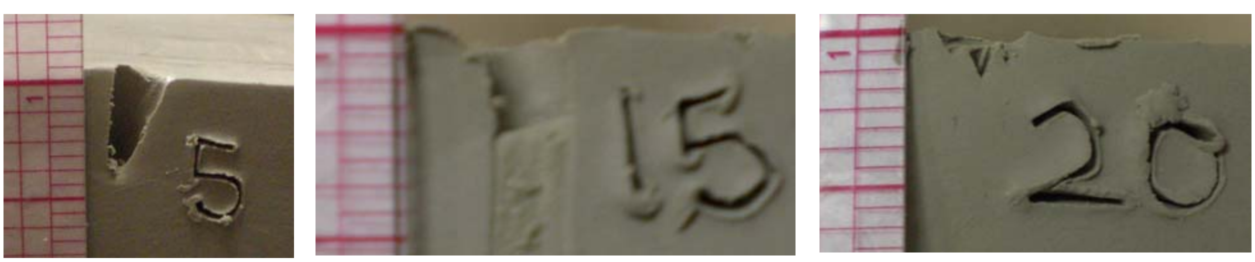
In order to capture this data, the researchers utilized the penetration data from Probe 1 from each CED as this was the most accurate based upon probe spread. Probe 1 also had the least amount of variation from point of aim. Probe 2 data was not captured as the creation of a wall of clay to address probe spread was not feasible. In order to measure the depth of the probe and barb penetration, the ballistic clay was cross-sectioned with a surgical saw and a digital image was captured. A graph ruler was used to measure the distance of penetration.

Figure 24: Ballistic clay



TASER: At the 5-foot distance interval the TASER probe and barb penetrated completely past the base of the probe. The base of the probe penetrated approximately 7/16 of an inch.

Figure 25: TASER Probe Penetration



At the 10-foot distance interval the TASER barb penetrated fully and the base of the probe also penetrated the ballistic clay to about the same depth as probe base at the 5-foot distance interval.

At 15 feet of firing, the TASER probe barb penetrated the clay completely. The probe base penetrated the clay to about 4/16 of an inch. This is consistent with a projectile that is losing some of kinetic energy.

At the 20 foot distance interval the TASER probe barb penetrated the clay completely and the probe base penetrated marginally to about 1/16 of an inch. This is no surprise as 20 feet of distance the probe will have lost more of its kinetic energy and is nearing the limit of its range.

Stinger: Stinger cartridges were fired at the various distance intervals. In order to obtain at least 10 data points at least 30 Stinger cartridges were fired (this was done to compensate for cartridge malfunctions). The Stinger probe penetration data was eventually based upon 10 captured observations. The Stinger probes at the 5-foot distance interval penetrated 3/16 of an inch past the base of the probe barb.

Figure 26: Stinger Probe Penetration

At the 10-foot distance interval the Stinger probes penetrated to the base of the probe and the barb was fully embedded in the clay.

At the 15-foot distance interval the Stinger probes barely penetrated the ballistic clay. The barb section of the probe did not pass the threshold of the surface of the clay, and if this were a subject, it is possible that the probes would not have penetrated the skin but may have penetrated an outer layer of clothing. This is illustrated in the below photograph where the top probe dangles from the shirt on the target.

At the 20-foot distance interval the Stinger probes were not tested as they failed to extend to this reach due to cartridge malfunctions[3].

While the use of clay to measure kinetic energy and penetration is not an exact measure, it does illustrate the changes in velocity over distance. It is clear that the light Stinger probe penetrates deeply at close distances, but quickly loses its ability to penetrate even a soft target.

Figure 27: Stinger Probe Penetration on Target Dummy

[3] In this test, the wire tethers were not allowing for full extension as they were becoming bundled and knotted.

Ergonomics Testing

Both the Stinger S200 and TASER X26 are relatively similar in exterior design. The TASER X26 overall is slightly smaller than the Stinger and a person with larger hands may have some issues with handling. The Stinger S200 is longer initially, however when the TASER X26 is loaded with a cartridge, they are similar in length.

The cartridge release feature was scrutinized in both CEDs. The TASER X26 cartridge release consists of depressing a small button on each side of the cartridge. The Stinger cartridge release mechanism consists of an ambidextrous button release in the trigger guard housing, which allows for one handed cartridge removal.

Figure 28: Stinger Cartridge Release

Both the Stinger and the TASER are pistol-like and both have triggers set in a trigger guard. TASER's Safety/On/Off switch is much like the safety on a standard semi-automatic pistol, while the Stinger utilizes a cross bolt (similar to that of shotgun) safety switch for on and off operations.

TASER: On/Off switch was found to be a weakness in its design. Throughout testing, several TASER X26s were shipped back to TASER International in order for them to repair this switch, which when malfunctioning, would not allow the CED to activate. Communications with local law enforcement agencies confirmed that this is a well-documented problem and agencies are required to repeatedly return the TASER X26 to the manufacturer for repair. As a result, many agencies purchase extended warranties to cover the expenses of these repairs, which is approximately $150.

This is problematic as there is no sign of the weapon breaking down until it suddenly won't turn on. Consequently, it is important for officers to at least test their weapon prior to starting their shift, if not conducting an additional safety check during the shift.

Figure 29: Stinger and TASER Safety Switches

Stinger: The Stinger On/Off cross-bolt switch was also a weakness in the design of the Stinger S200. During testing, this switch was found to have a specific malfunction. Should the user make contact with the cross-bolt switch while the Stinger S200 is discharging a cycle of current, the user also receives a shock for the duration of the cycle. There is no consistency to when this occurs, so the researchers of this current study are unable to make specific suggestions for fixing the problem. However, if the user were to activate the cross bolt safety while the weapon is firing, this shock occurs much more frequently.

Both the Stinger and TASER use standard classic line of sight sighting (iron sights) as well as a red dot laser sight. The TASER red dot sight appears at 15-feet to have a finer, crisper red dot (when projected on a standard flat surface) while the Stinger has a slighter larger red dot image at the same distance. Additionally, the TASER X26 is equipped with a front tactical light, while the Stinger weapon system is not.

The ergonomics of the Stinger S200 and the TASER X26 are also highly contingent on the manner in which the CED is carried during standard duty shifts. Thus, the holster or retention system needs to be addressed. The researchers were able to locate a wide variety of holstering and carry systems for the TASER X26. This is presumed to be the case as TASER has penetrated the law enforcement market extensively. The result is numerous options of retention for various types of duty.

Figure 30: Examples of TASER and Stinger Holster Systems

The Stinger S200 appears to be offered standard with a single retention nylon based holster. This holster is included in the Stinger S200 standard package. Should Stinger penetrate the law enforcement market more extensively, then it is surmised that additional products will become available.

The researchers tested the TASER X26 and the S200 in the standard offered holster system as part of the ergonomics evaluation. The following issues were observed:

TASER: The TASER X26 ships with an exoskeleton plastic and nylon based holster system that retains the X26 though an insert-and-click-in-place mechanism that grips the X26 and secures it firmly. This holster system has a belt attachment clip which allows for the holster to be tightened onto any carry belt.

The exoskeleton holster poses an issue in that it secures the X26 in such a secure manner that makes it problematic to draw. Furthermore, when drawing from this holster system, the cartridge has the potential to be unintentionally stripped from the X26. It is additionally difficult to replace the weapon (one handed) back into this holster system. This action, facilitated more easily with two hands, is still challenging. Other TASER holsters examined, such as the Blade-Tech line did not present these problems and the wide range of carry options provided the ability to meet individualized needs.

Stinger: The S200 ships with a basic nylon single retention reversible holster system[4]. Although we were not able to identify any other holster systems designed specifically for the Stinger, it is likely that some will emerge as this weapon gains market share.

The basic nylon holster was identified as presenting an issue with the operations of the Stinger S200. The researchers found that when carrying the Stinger S200 in this standard holster the cross-bolt switch was easily accidentally depressed, thus activating the weapon. Given that the Stinger S200 does not have an automatic shut-off feature, this presents serious issues as the CED batteries would drain. Additionally, the CED when drawn from the holster would be in a live mode, perhaps with the user unaware, posing a safety hazard for accidental or unintended discharges.

[4] This holster is very similar to the brand of "Uncle Mike's".

Figure 31: TASER Cam

Video and Memory Storage

The Stinger S200, at the time of testing, does not ship with audio or video recoding capability (the S400 appears to have this capability).

The TASER X26 allows for a digital camera attachment in the grip of the weapon with audio and video storage capability.

In addition to this storage capability, the TASER X26 camera and audio data is retrievable through download computer via USB adapter. This allows for the playback of an “incident”. The camera activates and records when the TASER on/off switch is turned to the on position. The data is stored in a database format and allows for an agency to download the data which is unique to each TASER via serial number. The following images show this process and a screen shot of the video as it plays back for review.

The below image is a screen capture shot of the TASER Cam download software when it is initially loaded. This allows the user to input data specific to the user of the TASER and is useful in tracking officers' uses of force.

Figure 32: TASER Cam Data Download – Version 1

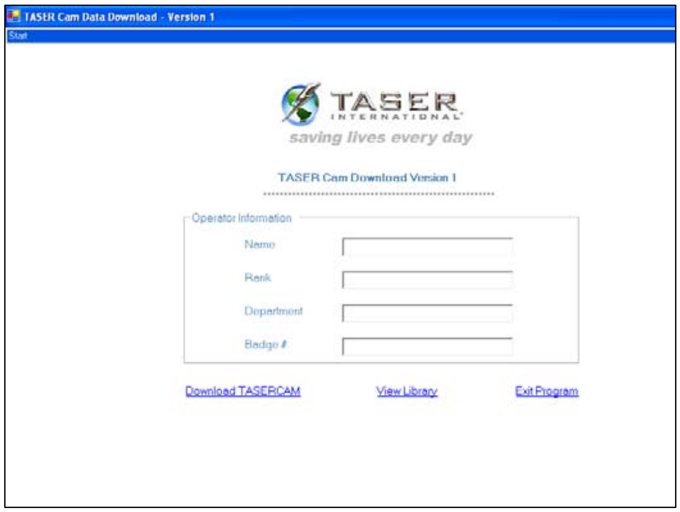
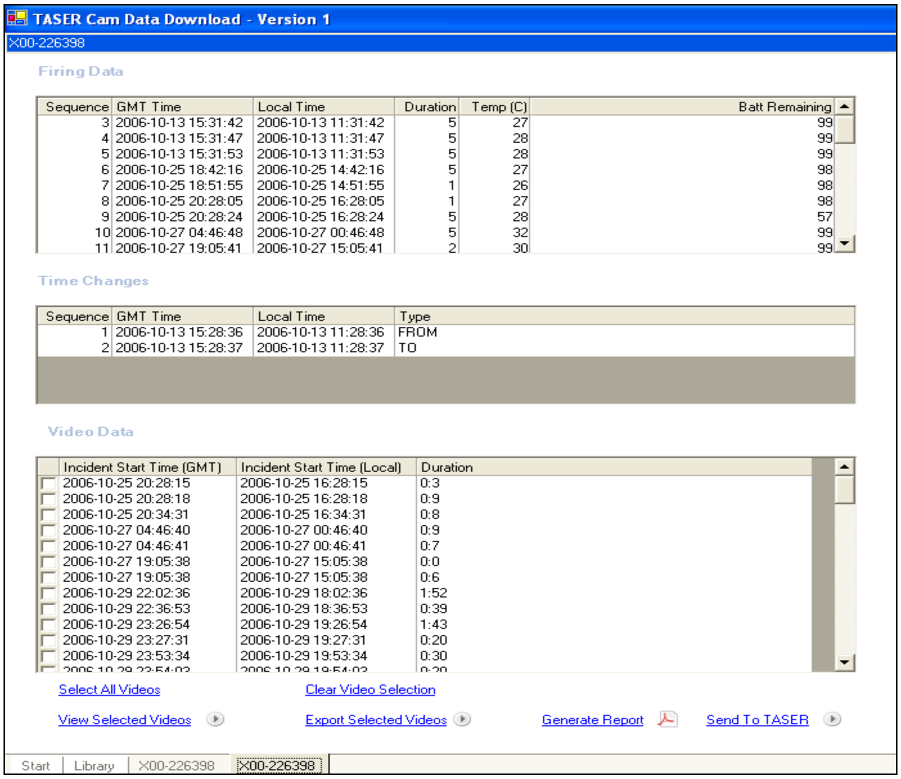


Figure 32 represents the data screen as viewed by the software user and allows for the selection of video data based upon time interval or sequence. This screen also allows the administrator to view or even export selected video or generate a report from a selection of one or more data captures/incidents. The researchers utilized this function of the TASER X26 to test its functionality. This feature of the TASER was easy to use and generated reports (in a .pdf format) easily. In addition, the videos exported by this software were viewable by a number of commercial video software applications.

Figure 33: TASER Cam Data Download (By date and time)



The researchers utilized the TASER X26 standard camera and recorded video as seen in Figure 34. The video on the left was recorded during the day, as noted the clock was not set on the TASER correctly and it reads 22:01 hrs. This image was recorded during the late afternoon. The image on the right was also recorded during the day and reflects an interior (house) shot (as in the previous shot the clock time setting is also wrong). Noted in this image are the red-dot laser sight and the TASER X26's camera light which can be activated in this lower light environment.

Figure 34: TASER Cam Shots (Exterior and Interior)

As with all digital cameras the TASER X26 digital camera is susceptible to the same problems of light, dark and position in relation to light source. As with regular photography, the image may become blurred with speed and or distorted by sunlight or other light sources. Additionally, the TASER X26's camera mounts to the base of the pistol grip; in cases where a user has oversize hands, there is the potential to block the camera while filming. In testing, the researchers found that if the camera is blocked while the TASER X26 is activated, the LED display flashes to warn the user.

The TASER X26 also stores audio data and audio recordings which begin when the TASER X26 is activated. The researchers activated the TASER X26 and captured audio recordings and listened to them after the captured data was stored to computer via USB port. This audio was exported with the video clips and is of reasonable audio quality. The audio captured was at the speaking voice level and the researchers did not experiment further with louder or lower or higher pitch sounds.

Figure 35: Issues with TASER Cam and Auto-focus

Touch Stun

The Stinger S200 and the TASER X26 both have touch stun capability. Both CEDs require that a cartridge not be in place, or to be removed, when using this feature. The TASER S26 and Stinger S200 have an additional feature which allows the CED to discharge a stun in a contact mode, once the cartridge has already been fired. It must be added that in this case, the probes, and to what or whoever they are attached, may also be shocked.

Timing System

TASER: The TASER X26 normally cycles for 5 seconds. The user may interrupt the X26 cycle by engaging the on/off switch to the off position. The X26 LED displays a numerical countdown for the cycle, which is easily observable by the user. The X26 will fire continuously for 5-seconds with one application of the trigger.

Figure 36: Stinger and TASER Displays

Stinger: The S200 has a standard cycle of 4-seconds when the trigger is continuously depressed. At the end of this cycle, the trigger must be released and then reengaged to cause a 4-seond cycle. The trigger may be released at time during the cycle, which causes the Stinger to cease firing. This allows the user to select, up to 4 seconds, the length of charge a subject may be exposed to. The Stinger S200 LED display represents this cycle as a series of red dots that move from the left of the LED to the right. Each LED that subsequently lights represents 1 second.

The Stinger S200 LED display also shows it is activated by displaying a green LED light.

In comparing the two CEDS, the TASER LED readout also presents system diagnostic information at time of insertion of the DPM which includes warranty expiration date (in order of year month day), current date and time, current internal temperature in Celsius and software revision level.

Figure 37: TASER battery status indicating 86%

After the TASER is powered, the LED readout also represents other data when the X26 is activated to include, percentage of battery power remaining and at time of trigger depressing, the LED readout shows time remaining on the 5-second cycle.

Propellant Systems

The TASER X26 cartridge is powered by compressed nitrogen, which when ignited force the probes to accelerate from the cartridge towards the target. The Stinger S200 cartridges are markedly different.

The Stinger S200 cartridges are fired by a primer which when activated through combustive pressure, forces the probes to deploy.

This method of causing the darts to deploy has significant legal implications for Stinger, as they are categorized by the BATFE as a firearm, and are viewed no differently than a regular firearm. Accordingly, anyone convicted for a felony, who has not had their rights restored, would be violating federal law if found with a Stinger S200 in their possession.

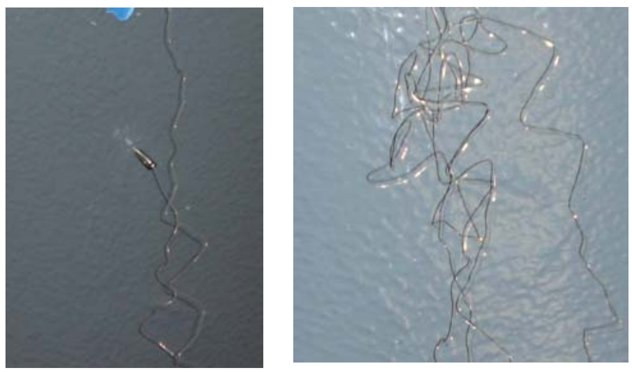
In addition, firearms manufacturers have recently won a case wherein their liability has been reduced. In this case the Stinger S200, being categorized as a firearm, may benefit from the legal benefits of such. It is unclear if this would have any effect on law enforcement agencies.

Freeze Test

Cartridges from both the TASER X26 and the Stinger S200 CED were placed in a controlled frigid environment of approximately 30º. The cartridges utilized for this portion of the testing were allowed to freeze for a period of 24hrs.

The cartridges from both the TASER X26 and Stinger S200 all fired and accuracy was consistent with previous results. The freeze test did not appear to affect the performance of the cartridges[5]. Weapons were not frozen as it has been clearly documented that cold will have an adverse affect on virtually every commercially available battery.

Figure 38: Normal and wet wire



Heat/Humidity/Water Testing

In this phase of testing, the cartridges (ten from TASER and ten from Stinger) were allowed to become exposed to the elements for seven days. The cartridges were exposed to an ambient temperature of about +-95º Fahrenheit from 06/22/2007 until 06/29/2007. The cartridges were also exposed to several rain showers and the researchers also dowsed the cartridges with water. This dowsing was intended to simulate an excess of humidity. All the cartridges from the TASER X26 cartridges fired in this experiment, while three of the S200 cartridges failed to fire. Upon examination of the probe tether wires, it was clear

[5] In this case the CED's were not frozen and were fired with them being at the ambient room temperature of 78º.

that the moisture had affected their function. The tethers in these cases appeared, when handled, to have a more rigid feel and were not as flexible when compared with tethers that were not exposed. This crinkling or accordion effect may affect functioning as the tethers may have reduced velocity of the probes and the resultant penetration.

Ignition Test

There is some anecdotal evidence suggesting that certain chemical agents will ignite when exposed to a charge. The researcher conducted a simple experiment with the TASER X26 and Stinger S200 in order to determine whether this proposition would hold true. To test this hypothesis the researcher dosed a target with 1-second burst of Capstun, a commercially available chemical agent that has an alcohol-based carrier.

The target did not ignite when shot with the probes of TASER X26 and the Stinger S200 before the application of the chemical agent. However, when a contact shot was made with each CED to the chemical agent affected chest area of the target, both weapons ignited the target. When the residual chemical agent and the alcohol based carrier ignited, the flame appeared with a yellow consistency indicating low heat and a slow burn. The flame was allowed to burn for 15-seconds and was then extinguished. An examination of the targets affected area under the shirt revealed no burn indications. It is speculated that the shirt serves a wick like function and its absorption the chemical agent is what allowed the ignition to take place. This issue relates to the chemical agent, much more than the CED. Any ignition source, including a lit cigarette, may create this effect depending on the chemical makeup of the agent. Consequently, awareness of the specific chemical agent brands using flammable carriers is the best preventive step.

Figure 39: Chemical Agent Ignition Test

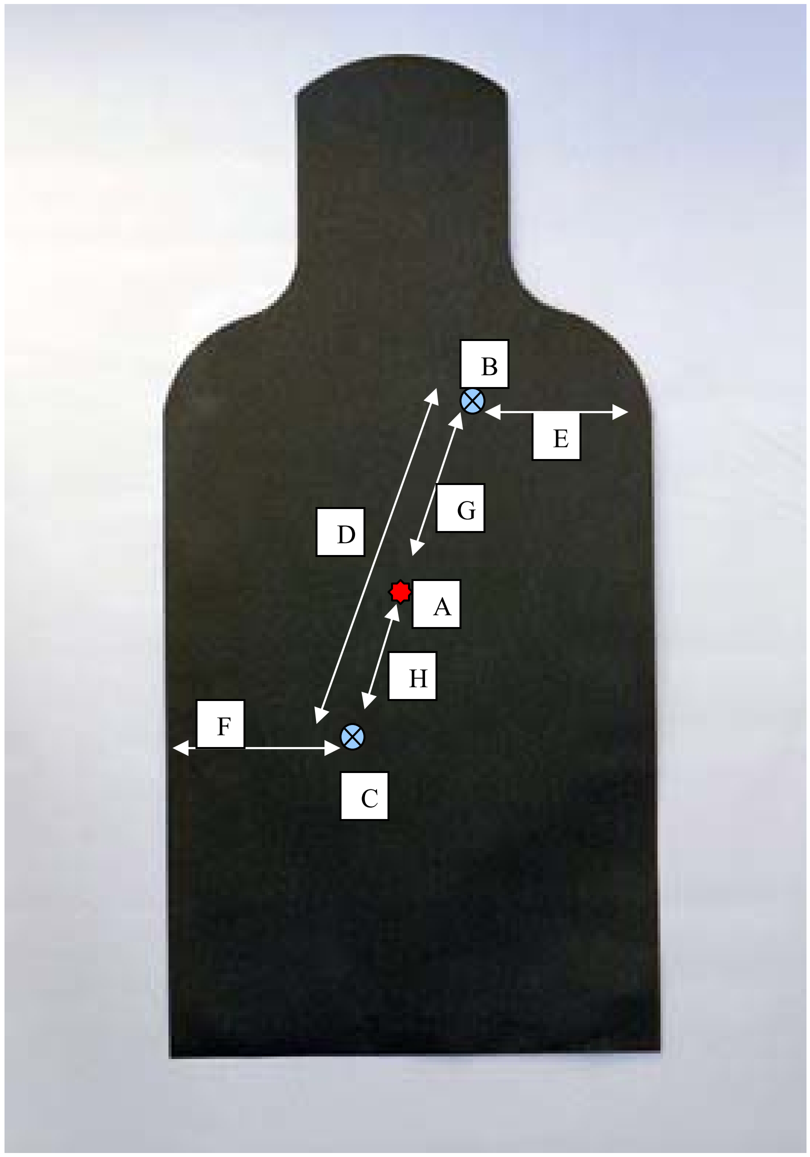
Additional flammability issues

Another anecdotal issue focused upon the explosion of a disposable lighter when struck by a CED probe. This concern was possibly created by an event which occurred in Daytona Beach, Florida. A suspect armed with a knife was shot by a TASER and a butane lighter was ignited by the probe strike (Local 6 News, 2006). Although the suspect received only minor burns, concerns regarding future safety requirements were brought up by the news media.

We attempted to replicate this event under controlled conditions but were not able to do so. Although we were able to strike the lighter and vent the butane, no fire resulted. It is clear that if a flame source had been present, a small fireball would have resulted. However, this is a very unlikely event.

Figure 40: Lighter Impacted by Probe

APPENDIX 1, Figure 41 Graphical Representation of FPF Variables



Legend

A: Laser Dot Aim Point
B: Point of Contact for Probe 1
C: Point of Contact for Probe 2
D: Distance between Probes 1 and 2
E: Distance to miss (Probe 1)
F: Distance to miss (Probe 2)
G: Distance from Laser Dot to Probe 1
H: Distance from Laser Dot to Probe 2

APPENDIX 2 Figure 41: Malfunction Explanations

Stinger S200	
Case#	Malfunction
2	Cartridge Failed to Fire (FTF) after being subjected to freezing temperatures.
9	Weapon sounded odd when fired. Weapon popped opposed to bang – barb possibly missing from cartridge.
19	Probe bounced off target and landed 12 ft from target.
45	Weapon cycled for 1.5 seconds before cartridge deployed.
47	Weapon cycled for .5 seconds before cartridge deployed.
52	Cartridge misfired on first full cycle – exchanged test weapon and cartridge fired appropriately.
85	Weapon cycled for 1 second before cartridge deployed. Probe hit in arm.
87	Probe broke off of wire with a 2 inch piece of wire lead attached. Probe did not impact target.
89	Weapon cycled for full cycle without probes discharging. Cartridge was removed and placed in second Stinger weapon. The weapon cycled for 1.5 seconds before firing.
95	Probe landed 5 feet short of target with wire attached.
96	Probe landed 8 feet short of target with 1 inch of wire attached. Wire in cartridge is still wound tight.
97	Probe bounced off of target and landed 12 inches in front of target.
127	Probe broke from lead. Wire remained coiled inside cartridge. Probe landed 3 feet short of target.
128	Weapon cycled for 5 seconds without firing. Cartridge moved to second Stinger and fired after 1 second delay.
131	Cartridge deployed after a 3.5 second delay. Only one probe went downrange and missed the target.
132	Probes broke wire leads and only one probe traveled down range to the target. Probe two did not travel to the target.
133	FTF in the first test weapon. Only one probe deployed correctly, while the other failed to travel downrange. *The weapon also shocked the operator of the weapon.
136	Cartridge FTF in the first weapon. The cartridge functioned properly in the alternate weapon.
176	Weapon cycled for 3 seconds before discharging with loud popping noise.
177	FTF.
179	Barb retracted into probe.
185	Probe broke off of wire during firing.
193	Cartridge came loose and shifted forward upon firing.
198	One probe failed to reach target.
206	Blast door hit operator in face.
207	Blast door came back and hit tester. Probe #1 crept up and hit neck area of target.
209	FTF
211	FTF
215	Probe broke off upon discharge. Wire failed to uncoil and leave cartridge.
218	FTF
220	FTF
221	Cartridge dislodged upon firing
222	FTF
227	FTF

229	Weapon cycled for .5 seconds before firing. Both probes made contact.
231	Weapon cycled for .5 seconds before firing.
233	Weapon cycled for 5 seconds without firing. Cartridge was removed and placed in second Stinger weapon. The weapon cycled for .5 seconds before firing.
234	Cartridge dislodged upon discharge.
235	Cartridge dislodged upon discharge.
237	Weapon cycled for .5 seconds before firing and cartridge dislodge upon discharge.
238	FTF
239	Cartridge dislodged upon discharge.
241	Weapon cycled for 1 second before discharging.
243	Probe #1 crept up to the neck area of the target
246	FTF
251	FTF
252	FTF
255	FTF
256	Weapon cycled for .5 seconds before firing.
258	Same as #256
266	FTF
268	Probe #1 broke off from wire upon discharge.
269	FTF
271	FTF
***Stinger S200 (new cartridges)**	
293	Probe #2 bounced off of target
326	Probe #2 bounced off of target
328	FTF
361	Neither probe made impact
364	Probe #1 made no impact
TASER X26	
35	Probe bounced off target fell 1ft back from target.
42	Probe #1 broke the wire lead before impacting target. Probe #2 missed target.
37	Probe#2 made contact with only 1 inch of lead wire attached.
380	FTF. Accidental discharge occurred when new battery was placed in weapon. No trigger pull occurred. Power switch was not completely set to the on position. Probe #1 stuck in carpet 6” from tester’s foot.
381	Laser pointer faded in and out before becoming solid, once power switch was set to on.
409	Probe #2 broke off of wire upon discharge. Wire still coiled in cartridge.
427	Probe #1 broke off of wire upon discharge. Wire still coiled in cartridge. Probe #1 also bounced back and hit tester.

U.S. Department of Justice

Office of Justice Programps

National Institute of Justice

Washington, D.C. 20531

January 28, 2008

Dear Sirs:

We are providing the draft final report: *A Qualitative & Quantitative Analysis of Conducted Weapons: TASER X26 vs. Stinger S200* for your review. This study by Florida Gulf Coast University's Weapon's & Equipment Research Institute was conducted as an impartial analysis that provides qualitative and quantitative data regarding these products. To maintain objectivity, we are offering both organizations the opportunity to review the study and provide comments accordingly.

Please take this opportunity to review the report and provide comments no later than February 04, 2008. We ask that your comments be factually based and address areas in the study that your literature can support (i.e. X26 or S200 specifications, operational and cost discrepancies), and limited to 5 pages. We will entertain including these comments in the report, upon receipt.

Operational Technologies Division
National Institute of Justice
810 7th Street NW
Washington, DC 20531-0001

PROTECT LIFE

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Marc Caplan
Chief, Operational Technologies Division
National Institute of Justice
810 7th Street NW
Washington, DC 20531-0001

Dear Mr. Caplan;

In response to your undated letter addressed to Andrew Hines at TASER International, Inc. (TASER) which was received by TASER on January 30, 2008, following please find our comments to the January 25, 2008 NIJ report entitled "A Qualitative & Quantitative Analysis of Conducted Energy Weapons: TASER[®] X26 vs. Stinger S200", by Charlie Mesloh, Ph.D., Mark Henych, Ph.D., L. Frank Thomson, MBA, and Ross Wolf, EdD.

a. In the section that describes TASER lower probe misses at 20' - the experiment does not accurately match field use because the Numb John target has his legs spread in an unnatural stance. In actual field-use applications, the human subject has his/her legs under the torso. At these longer distances, the lower TASER probe trajectory is designed to hit a target in the legs providing ample spread to cause NMI. The artificial stance of the dummy target left an open space where one's legs would normally be expected, and the probes projected through this open space consistently and accurately. However, the test set-up and interpretation that the lower TASER probes were missing the target draws a misleading conclusion as to the accuracy and repeatability of the TASER probe trajectory in real-life scenarios.
b. Pg 73 - Safety weakness - the concern had been previously identified and has been remedied. The design and assembly process for the safety switch was modified to improve performance and eliminate potential inconsistencies in the weld of the parts. Since this modification has been implemented, the incidence of broken safety switches has fallen to a negligible number.
c. Pg 76 - eXoskeleton™ holster - the concern regarding the holster unintentionally stripping the cartridge had previously been identified and remedied. The release buttons on the cartridge used to protrude in a convex manner, allowing the holster to depress the release button under certain circumstances. The release buttons on the cartridge were inverted to a

concave indentation, thereby preventing mechanical interference with the holster that could inadvertently dislodge the cartridge, thereby eliminating this possibility.

.

Very truly yours,

Douglas Klint
Vice President and General Counsel

Stinger™ SYSTEMS

DEDICATED TO THE SCIENCE OF OFFICER AND PUBLIC SAFETY®

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866.STUNSHOT
www.stingersystems.com

February 2, 2008

Mr. Marc Caplan
Mr. Davis Hart
National Institute of Justice
810 7th Street NW
Washington, DC 20531-0001

Dear Sirs:

Thank you for giving Stinger Systems an opportunity to comment on the DOJ analysis of the Stinger S-200 vs. the Taser X26.

The weapon you tested is no longer sold by Stinger Systems and therefore this comparison should be considered suitable, applicable, or current. In this letter I will provide comprehensive documentation that clearly illustrates that the gun you tested is a completely different weapon that the gun that is now being sold by Stinger. **The only thing that is similar between the current S-200 and the one tested is the name.**

Florida Gulf Coast University pressured Stinger Systems to provide it with a weapon when it fact, the gun was still in Alpha shipping state. The weapon they received was a first generation product that, in further market analysis, the Company quickly realized needed substantial revisions. The original design was ultimately scrapped and completely redone to what is now being offered by the company. **None of the aspects of the gun tested, except the basic look of the gun, remain**.

Distributing this document in my opinion be of no value and not a responsible action by the DOJ. The document would clearly provide a false representation to the law enforcement community what is genuinely available. Further, This report would provide Stinger's competitor with marketing material that would not be representative of a valid Stinger vs. Taser comparison. This action would genuinely be a disservice to those agencies and departments that seek accurate data regarding EID technologies.

Stinger Systems would welcome the opportunity to provide the DOJ with a "real" S-200 projectile stun gun. Additionally, because the output waveform is so radically different from the one you tested, Stinger Systems, is concerned that those who would read this report and would be lead to believe that information is correct about Stinger's current S-200 that they may decide to purchase a competitors product when the information is not current. Further, personnel from the University of Missouri completed additional medical testing this week and confirmed that the Taser X26 puts more amperage, voltage, and energy at the chest than the Stinger S-200. This data is very important and could only be achieved with **Stinger's new wave form and not with the wave form that the DOJ tested**.

ELECTRONICS:

The electronics in the S-200 the DOJ tested created the following data points:

Waveform:	complex pulse series
Pulse Duration:	300us and 400us
Trigger Activation:	programmable and manual up to 4 seconds
Peak Arcing Voltage	63,000 volts
Peak Loaded Voltage	1300 volts
Current	5.0 mA average
Energy per pulse:	
At Main capacitors	0.30 joule
Delivered into Load	0.072 joules
Power Rating:	
At Main capacitors	9.5 watts
Delivered into Load	2.3 watts

The electronics in the in the current S-200 create the following data points:

Output Characteristics:	
Waveform:	complex pulse series
Pulse Duration:	200 micro-sec
Trigger Activation:	programmable and manual up to 4 seconds
Peak Arcing Voltage	56,000 volts
Peak Loaded Voltage	1100 volts
DC Current	2.3 mA average
Energy per pulse:	
At Main capacitors	0.87 joule (available)
Delivered into Load	0.043 joules
Power Rating:	
Delivered into Load	0.94 watts

Clearly, these tables characterize different products.

As one can see in Exhibit 1, the wave form is radically different than that of the wave form created in the current model, illustrated in Exhibit 2. Exhibit 3 and 4 are photographs of the compartmentalization of the old S-200 and the new S-200 respectively. As one can see, even the circuitry is laid out differently.

We tried to contact Florida Gulf Coast University to notify them that the gun they tested is not an representative product to test and offered to provide a new S-200 but we did not receive a returned call.

From an energy efficiency perspective in the gun the DOJ tested, much of the energy was found to be lost between the high voltage module and the dart probes. Therefore not as much energy that was actually created was put forth into the subject. Stinger's engineering team set out to redesign the circuit. The team knew the basic concept behind its waveform and how it effects physiology was valid but needed to ensure that the actually energy leaving the transformer could be conveyed to the subject. Among some of the radical new design efforts the engineering team created was to implement a rectifier bridge. Re-calibration of internal software, and additional electronics to compensate for the dart wires and ground capacitance was also taken into consideration. Exhibit 5 shows the new high voltage module which contains the rectifier bridge. Going back to Exhibit 3, one can clearly see that this bridge is not contained in the older model.

Moreover, the winding scheme, the design, and the fabrication of the output transformer are completely different from the S-200 used in testing. Output transformers are among the most critical components of a stun technology.

Darts:

The darts used in the test, Exhibit 6, were unibody constructed and made outside of Stinger Systems. The barbs were inserted into a small hole in the dart and then swedged (crimped) in to keep it from being pulled out.

The Company this design had many issues, including the faults that were illustrated in the study.

The Company now uses a three piece dart for construction, Exhibit 7. During construction, a straight barb is passed though the forward component of the dart. Once through, the darts back end is flattened and then bent making it virtually impossible for the dart to be removed from the darts body.

Trajectories have changed drastically. After extensive analysis, several factors came into play when determining how to improve the flight patterns.

- First, as mentioned, the company changed the dart design and construction. All darts are now fabricated at Stinger Systems' manufacturing facilities and not a single aspect of the construction is made by a 3rd party.
- Second, the wire used in the DOJ tests we found to be unacceptable. The Company changed to a different wire vendor. The wire now being used has a different outside diameter and uses Dupont's Tefzel coating for insulation. This wire spools much differently which provides a smoother exit from the chambers. Therefore flight trajectory is more

reliable. Additionally, the new insulation provides for almost no possible shorting which could lead to mis-fires.

- Third, the cartridge's plastic housings themselves have been retooled and the exit paths, the construction, and the primer orientation have all been modified. These factors all assist in making a cleaner dart exit, which in turn, allows for a more reliable target attainment.
- Electrode placement in the gun, Exhibit 8. The electrodes of the gun have been moved from flush front of the gun (used in DOJ testing) to inside the gun and pointed downward. Ball springs are now used for electrode termination rather than rod aluminum. When a cartridge is now inserted into the gun, the cartridge is more secure because the electrodes now physically touch the cartridge where they hadn't in the past. Because they touch the cartridge, upon firing, the cartridge can no longer have as much play as it did in the model the DOJ tested. Moving a few thousandths of an inch we found could result in inconsistent firing patterns. Now that the cartridge is "locked" in place firing patterns are much more reliable.

Ancillary:

The Company has retooled every plastic injected mold that is used in the production of the S-200. The present S-200 is now more "tighter" and more rugged.

The Data Dock's program that is used for wireless downloading has been modified by reprogramming.

The actual vendors of electronics, plastic, and transformers have been changed.

Although Stinger Systems has spent millions of dollars developing what we believe to be the most state of the art EID product available, we are still a relative start up. With that being stated, we believe that to be a benefit because it allows the Company to continually improve its products and be very nimble. We therefore can adapt and improve very quickly to make the best product available. We believe we have a world class product and would very much like the DOJ to review a product that is now being sold by Stinger Systems and not one that has been retired.

Please contact me anytime at 813-281-1061 ext. 225.

Very truly yours,

Robert F. Gruder
President

Exhibit 1
DOJ Tested S-200
Please note the energy RMS of only 14.4V and the length of the wave

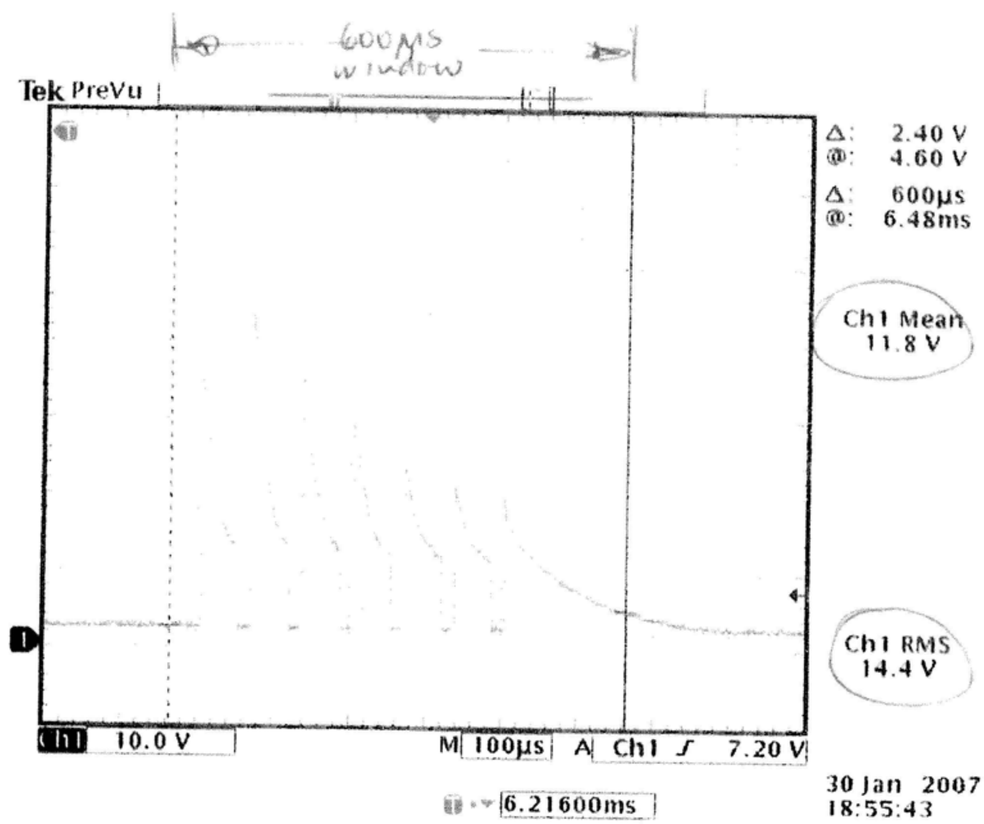


Exhibit 2
Current S-200
Please note the energy RMS of 26.5 and the length of the wave

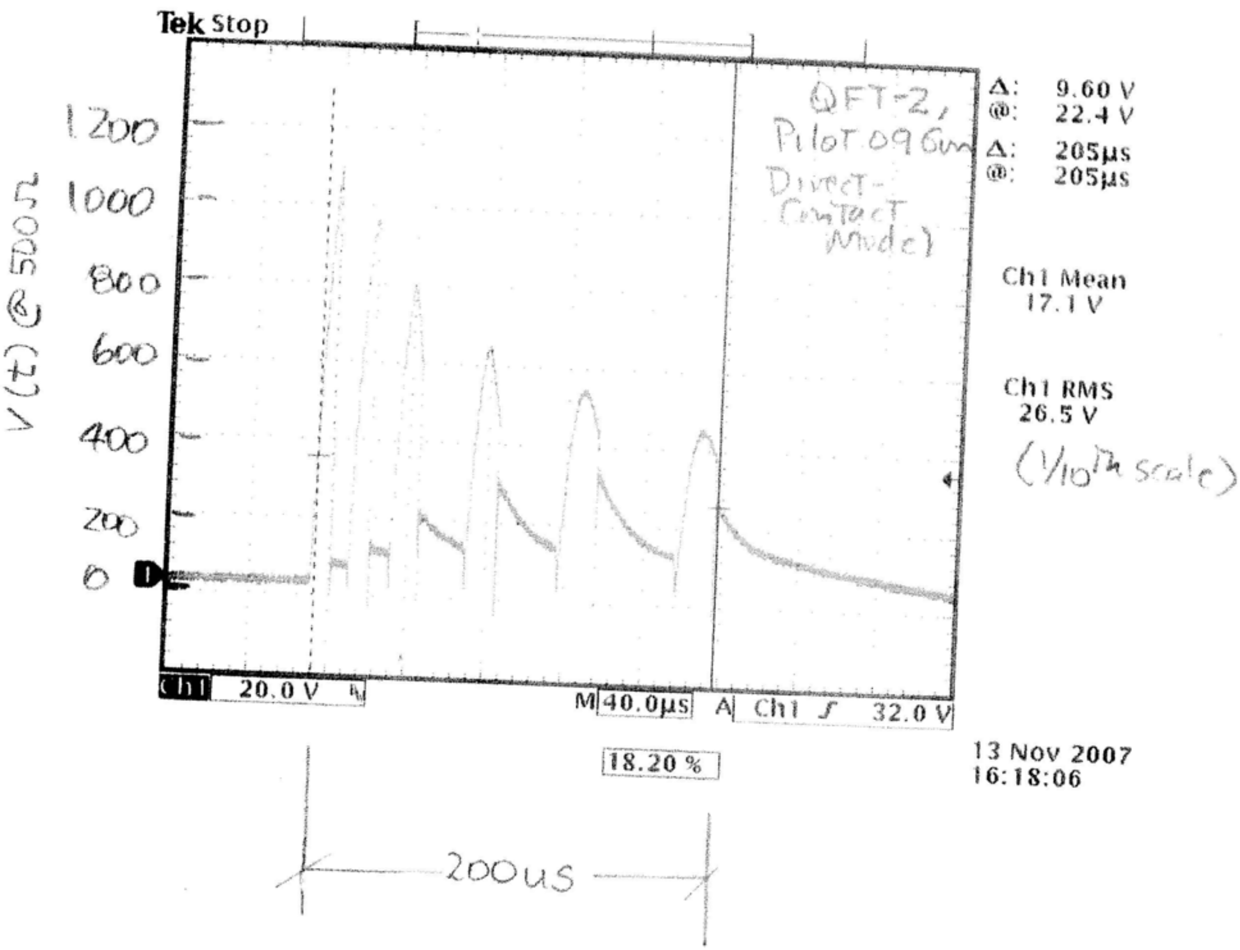


Exhibit 3
DOJ Tested S-200 Electronics Package

Please note there is no electronics board in the gun handle, the high voltage module arms extend to the end of the gun, there are no diodes in the high voltage module, there is a different output transformer and the trigger assembly is different

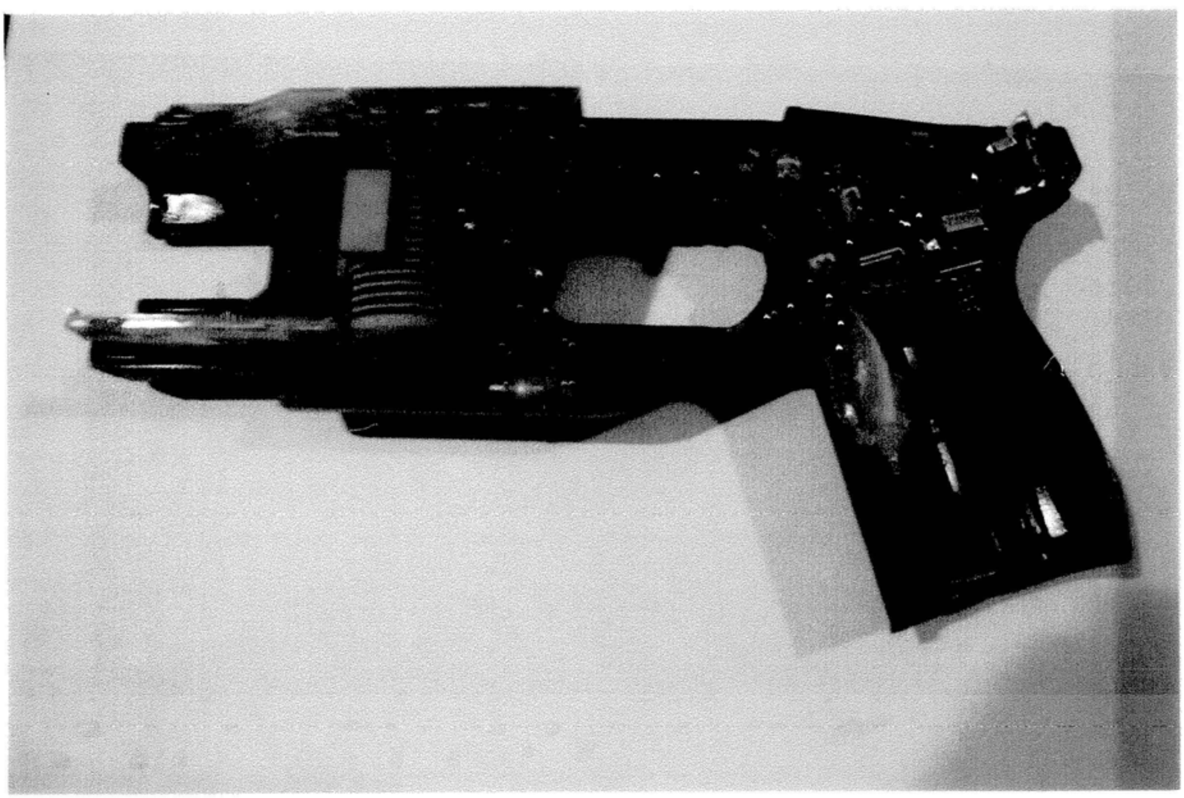


Exhibit 4
Current S-200 Electronics Package
Containing rectifier bridge in the high voltage module, a new trigger board assembly, and a logic board in the handle

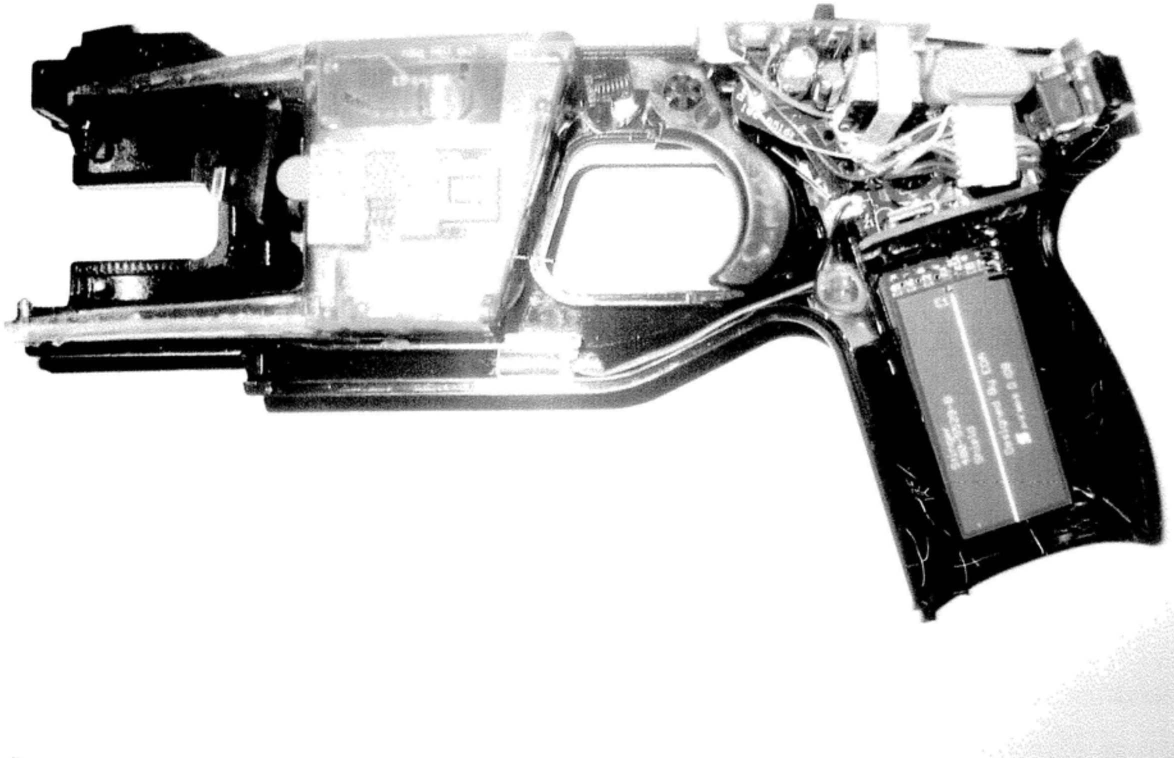


Exhibit 5
Rectifier Bridge Exhibits

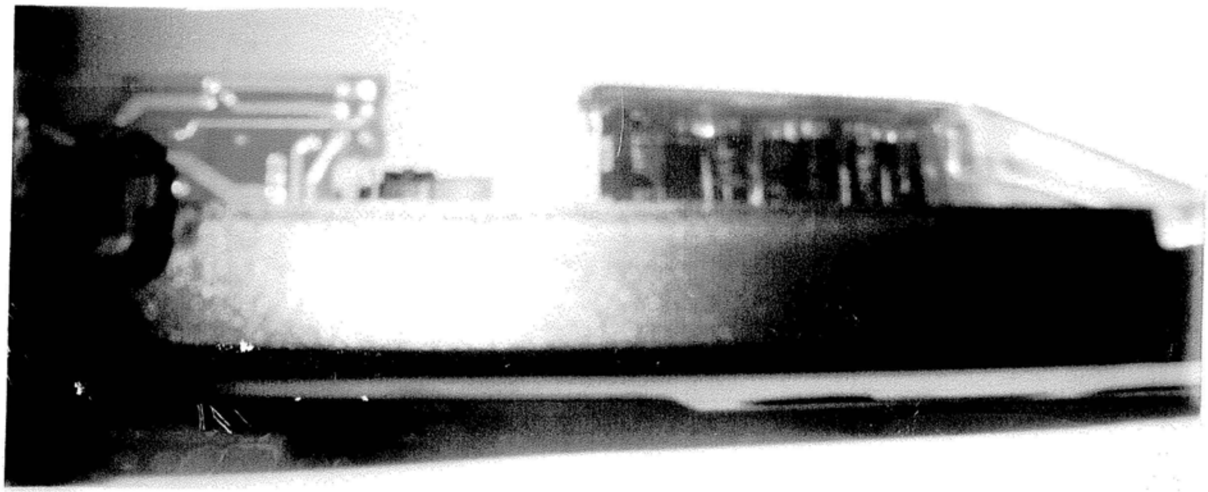
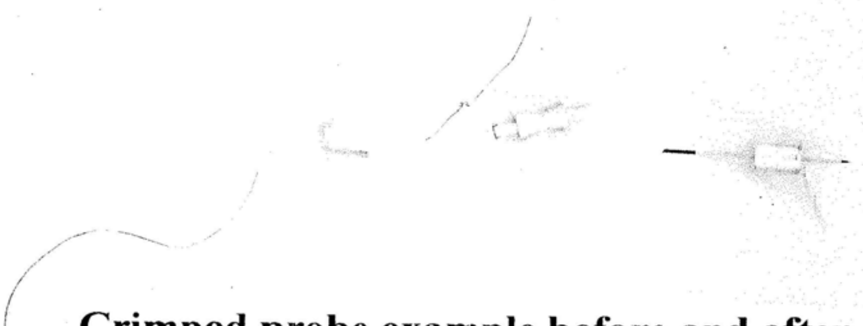


Exhibit 6
DOJ Tested Dart

Exhibit 7
Current Dart Configuration



Crimped probe example before and after crimping to show flattened steel that can not be pulled from dart body

Exhibit 8
DOJ Tested S-200 Electrode Placement

Rod placed to bring electrode flush to end

Current S-200 Electrode Placement

:lectrodes inside ›ointed down to lock n cartridge

Technical White Paper SS-WP-11

A Comparison of Stun Gun Waveforms

Stinger Systems, 2008

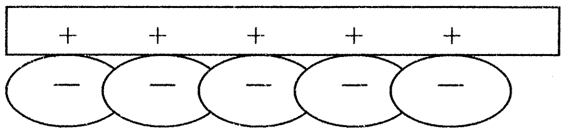
Introduction:
In this paper, we wish provide a clearer understanding of how the Stinger Systems S200 stun gun's electrical output waveforms compare to that of Taser's M26 and X26 guns and, further, how they impact a target's nervous and muscular system. We wish to show that "more is not always better" but rather that a biologically "smarter" waveform can be better for what Stinger Systems believes are a safer and yet very effective muscular incapacitation gun.

Separating the Men from The Boys:
Saying the Stinger is better because it has approximately 56,000 volts in an open circuit compared to Taser's 50,000 is really not the whole story. Yes, voltage is the "pushing" pressure, if you will, of electricity and generating more volts to push through clothes is a proper concept. However, Van De-Graff machines at museums (the contraption you put your hands on to make your hair stand straight up) are completely harmless yet generate up to a million volts in them. The difference is the amount and shape of the current passed through the body once contact is made. What is needed is something akin to a two- speed gear shift automobile – one gear gets you going from a dead stop and the other does the fast moving. Guns which can 'switch gears' is a big factor which separates the men from the boys in effectiveness. But as will be described, there are other factors such as cardiac safety.

Guns With a Two-Speed Gear Shift:
The design of an effective stun gun electrical waveform requires that the fired darts manage to arc and spark through the target's outer clothes and then, once an ionized-air and highly conductive plasma arc is established, the gun must somehow automatically shift gears, so to speak, and drive home (to the target body) a much larger electrical current but with lower voltage to cause effective involuntary muscle contraction. Further, once the plasma arc has been established, then the wave shape and timing of the subsequent electrical waveform is important for "smart" muscle contraction. That is, maximum contraction with minimal likelihood of cardiac arrest or other adverse body effects.

What Are We Trying To Do to the "Target"?
First, let's just state the simple objective of what we want an effective stun gun to do: "Override the body's electrical signals to the muscles to achieve immobilization". But to get this electricity to penetrate to the body's surface from possibly non-contacting darts we need that aforementioned very high voltage initially to "spark" a good contact, but once that contact is made, we then need to push a lot more current through the low resistance of the flesh so it can 'find' and trigger the nerve fibers. Think of the body as a large salt bag with embedded electrical wiring called nerve fibers. Then envision a nerve

fiber as being like a string of pearls placed inside of a drinking straw inside this salt bag. This straw is filled with salt water and in its resting state has a positive electrical voltage with respect to the inside of each 'pearl'. This salt water is filled with sodium ions whereas the inside of each pearl is filled with potassium ions. This is similar to a battery.



When a strong current is passed through the "salt bag", then these sodium ions get "pushed" through the "pearls" or nerve cell membranes and the potassium ions get sucked out causing nerve cells to trigger. Once triggered, they in turn contract muscles in an involuntary manner. However, this current (and voltage) must last long enough for this chemical process to push and pull ions across the "pearl's" outer shell to actually cause a nerve to trigger. This ion transport process requires that the voltage and current pulse be applied in **one direction** for about one-fourth to one-half millisecond (250 to 500 microseconds). Shock sensitivity curves were compiled by C.F. Dalziel (Ref. 1) which suggest that sinusoidal pulses much shorter than 250 microseconds rapidly become less effective at causing electrical shock.

Based on these biomedical shock sensitivity curves, a short pulse, say, 20 microseconds, is only about 25% as effective as a 200 microsecond pulse at causing perceptible shock. Therefore, single, fast pulses are poor candidates for efficient involuntary muscle contraction. **And recognition of this fact is one of the keys to making a 'smarter' waveform for a stun gun.** It becomes clear that gun waveforms which generate a single, very-short electrical pulse will have to output massively larger energies to force this inherently slow process to take place. The Taser M26 is a good example of this.

Relating Pulse Width and Polarity to Gun Performance:

The M26 Gun's Waveforms:

Now, when you look at the huge electrical voltage and energy levels of the M26 as shown in **Figure 1**, you'd instinctively say, "Wow, that has so much energy, it's the best". Wrong. The M26 has a very narrow pulse waveform which, as suggested above, is less effective. To make matters worse, after a massive short positive pulse, the M26 immediately reverses polarity. This in turn partially reverses the ion transport process that was started by the preceding large pulse! So what you really get is heating and pain with relatively little efficiency of muscle contraction. That is why, we believe, the engineers at Taser came up with the X26 waveform.

The X26's Waveforms:

Looking at the X26's waveform in **Figure 2** (Direct Body Connection) or **Figure 3** (simulated Clothed Target), you can clearly see that it is quite different from the M26's waveform. This wave has an initial large but narrow spark voltage followed by a single uni-polar pulse. Taser's specification sheet states that the duration of this pulse is about

100 microseconds, but the majority of the energy is actually spent in about 80 micro-seconds. This is indeed a step in the right direction – namely first ionize any air gaps between the darts and the conductive target's "salt-bag" and then immediately use that highly conductive path to apply a lower-voltage, higher-current unipolar-pulse through the target's embedded nerve fibers to force a large migration of the sodium and potassium ions across the nerve cell membranes. However, because Taser guns incorporate older gas-tube and spark-gap technology, their design has no choice but to completely dump the available electrical energy (in a capacitor) in one quick pulse. It appears to Stinger Systems that Taser did attempt to stretch it out but could not readily achieve the ideal 250 microseconds to 500-microsecond pulse width goal, which nerve fibers are "looking for" to optimally trigger muscle contraction. Thus, in Stinger Systems' opinion, the X26 gun had to also output excessive energy to accomplish their goals but not as much as the M26 gun. Stinger Systems believes that this excess energy could more readily compromise a subject's stressed cardiac system in a confrontational scenario than a lower energy 'smarter' waveform.

<u>The S200: Towards a 'Smarter' Stun Waveform:</u>

The novel *Quantum Flyback Technology*™ incorporated in the S-200 gun permits what Stinger Systems believes is a near optimal "designer" waveform to be created under microcomputer control. As shown in **Figures 4 and 5** for several target conditions, the wave consists of a series of relatively short, uni-polar pulses intentionally spread over a 200-microsecond interval. This gives more time for the ion transport to take place. By using a series of pulses, several benefits result. First, less total energy can be delivered over that interval while still optimally 'nudging along' the ion transport process with peak voltages in the 500v to 1000-volt range. Secondly, a series of short pulses is believed to be safer as described below.

The Other Key for a "Smart Waveform": Cardiac Safety:

A subtle but important factor in the design of what Stinger Systems believes is a safer stun gun waveform is the depth of electrical current penetration. An ideal waveform would "somehow" not penetrate deeply into the body where the heart or other organs could be adversely impacted. If the waveform's shocking currents could somehow be confined to the body's exterior muscle tissue, then it would logically appear to possibly not only be safer but would also be more effective since the exterior skeletal muscles are the very ones we wish to incapacitate.

High-frequency Pulses and the "Skin Effect":

An interesting phenomenon of high frequency electrical signals is that they tend to hug the surface of any conductor they travel through. (Ref. 2) If you once again inspect the waveforms of Figures 4 and 5, observe that the pulses have a narrow width – only about 15 microseconds. Such a fast pulse tends to not penetrate as deeply as a single long pulse. Note that these pulses are about 5 to 6 times shorter than the X26's pulse. So, this theory suggests that deep body penetration with the S-200 waveform may possibly be less. Note that any one pulse would unlikely cause a significant contraction. However, a series of them spread out over the important nerve ion-transport delay interval (0.2 to 0.5 msec.) is an entirely different matter … as test subjects will testify to.

Conclusion:
The design of a smart, non-brute-force stun-gun waveform is not trivial. The design factors of achieving a large target-connection spark followed by much higher current, bio-optimized waveforms at reduced voltages were challenging but have been solved, patent-applied-for and are now being produced in the S-200 Stun Gun. This *Quantum Flyback Technology*™ performs automatic electrical "gear-shifting" followed by near-optimum, less cardiac invasive, muscle-contracting electrical waveforms.

Ref 1: "Let-go current versus frequency curves", from C.F. Dalziel, "Electric Shock", *Advances in Biomedical Engineering*, edited by J.H.V. Brown and J.F.Dickson III, 1973, *3*, 223-248 (note: sinusoidal frequency to pulse width inference assumes that shock onset occurs during a one-half cycle period.)

Ref 2: "Noise reduction Techniques in Electronic Systems", by Henry W. Ott, Bell Laboratories, p144-147, John Wiley and Sons Publishers, 1976 ; (Electric current penetration is proportional to the square root of both frequency and the target's conductivity; so higher frequencies (smaller pulse widths) tend to penetrate less.)

Figure 1: The Taser M26 Stun Gun's Output Waveform
(Test Load has a 10:1 voltage reducer.)

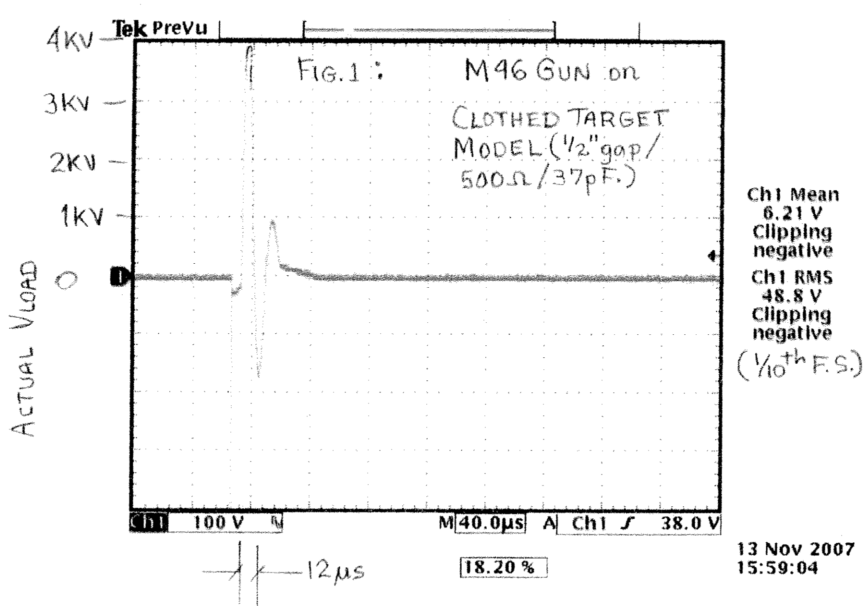


Figure 2: Taser's X26 Stun Gun's Output Waveform: Direct Contact Load
(Test Load has a 10:1 voltage reducer.)

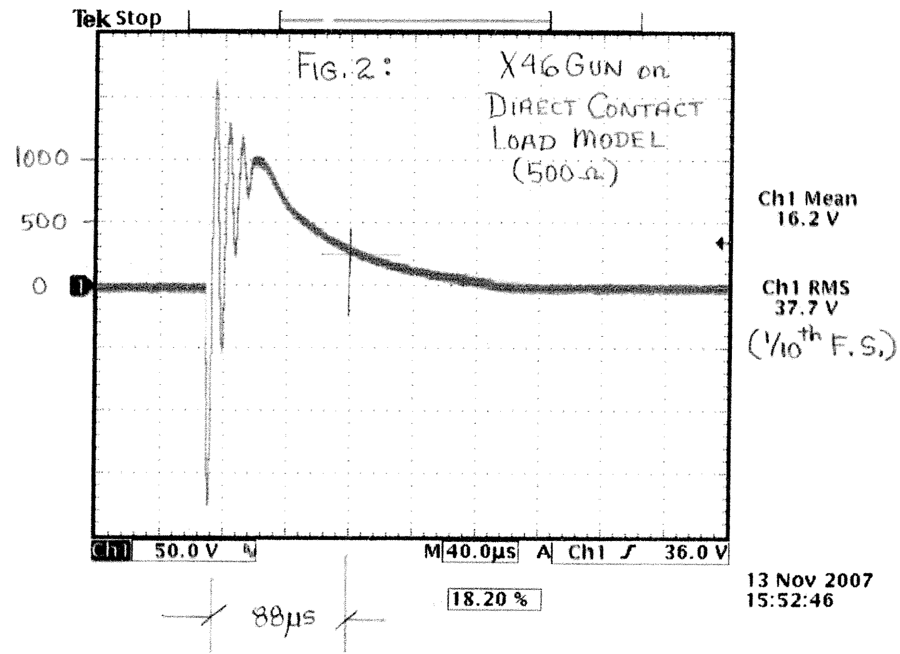


Figure 3: Taser's X26 Stun Gun's Output Waveform: Clothed Target Load
(Test Load has a 10:1 voltage reducer.)

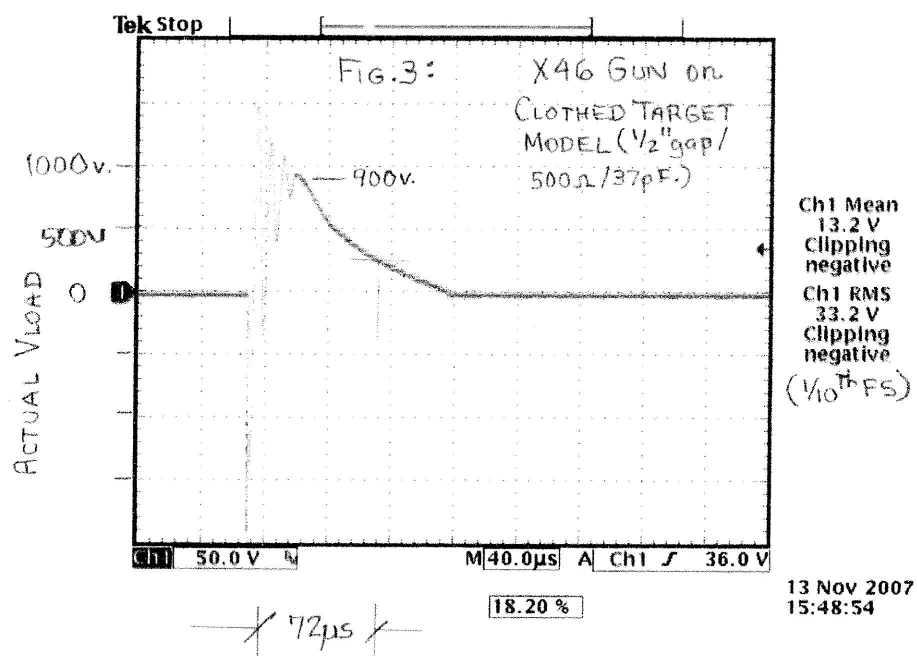


Figure 4: The S-200's Output Voltage Waveform: Direct Contact
(Test Load has a 10:1 voltage reducer.)

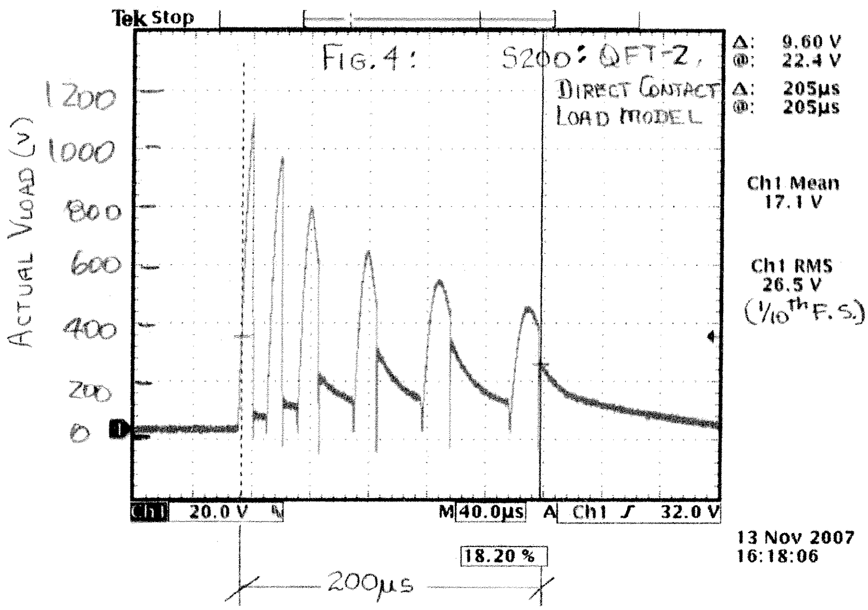
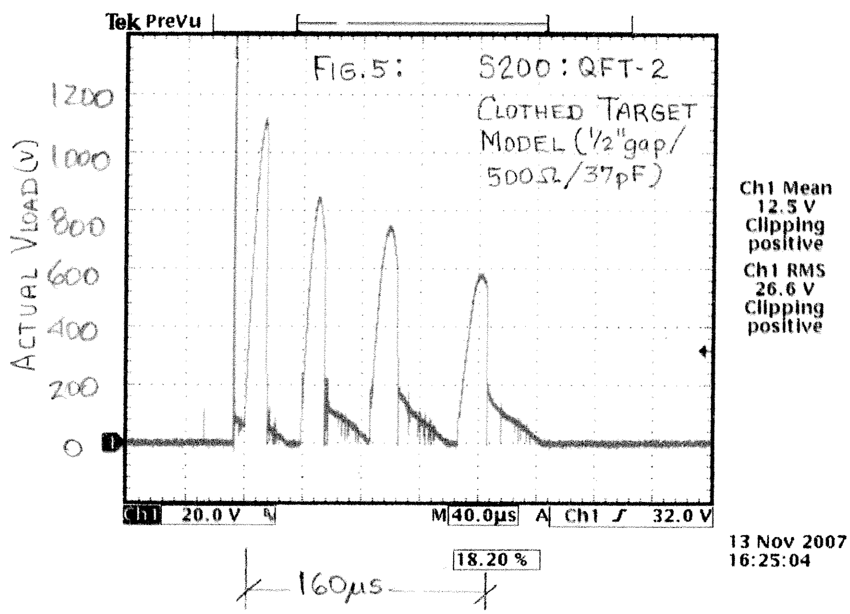


Figure 5: The S-200 Output Voltage Waveform: Clothed Target Load
(Test Load has a 10:1 voltage reducer.)



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