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The Attribute-Based Evaluation (ABE) of Less-Than-Lethal, Extended-Range, Impact Munitions

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Contents

Sidebar text highlights salient points throughout the report.

Executive Summary

When local police and military departments consider the procurement of less-than-lethal, extended-range impact munitions, there are only the manufacturer's specifications and performance characteristics upon which to base a "buy or not buy" decision. This report, co-authored by the Los Angeles Sheriff's Department (LASD) and Penn State University's Applied Research Laboratory (ARL), is a preliminary evaluation of off-the-shelf less-than-lethal munitions that will allow law enforcement officials a comparative basis for determining what munition is best suited to meet their requirements.

Less-than-lethal munition types were donated by various manufacturers and, over a two-day period, fired at a ballistic impact measurement device (pendulum plate) by LASD marksmen. A team of professionals with significant less-than-lethal weapon experience from both LASD and ARL characterized the munitions. All the munitions were assessed for accuracy and imparted momentum.

It is a rare opportunity to fire all of these types of munitions and certain observations were made during that time. Although it is not the intention of this report to endorse any munitions or manufacturers, some general observations are provided. Bear in mind that only five rounds of each type of munitions were fired. So these observations are about munitions taken as a whole and not about any particular munition type.

Accuracy issues

We were struck by the general inaccuracy of these munitions. Some configurations were more accurate than others but the accuracy decreased significantly as the range increased. There were very few direct fire munitions that could be used accurately at a range of 75 feet. For example, 37 extended-range impact munitions were fired at a range of 75 feet. Of those 37 munitions:

- 17 had accuracy dispersion of 18 inches or less (46%)
- 11 had a dispersion greater than 18 inches but equal to or less than 36 inches (30%)
- 9 could not reliably hit the impact plate (24% overall).

Reliability issues

Few things are more dangerous to a law enforcement officer than a misfire, and several misfires were observed. In each of the misfires, the firing pin had struck the primer. These misfires occurred primarily when the 37mm launcher was used.

There were occurrences of fouled bores where, after firing, the projectile failed to clear the barrel. In a tactical environment, detection of a projectile that remains lodged in the barrel may be difficult to detect and this presents a dangerous situation.

Large variations in imparted momentum for a single type of munition were observed. For example within the five rounds fired of a single type of munition, the highest imparted momentum could be almost three times as high as the lowest imparted momentum. The human effect impact of this type of variation could range from ineffective to tragic.

Skip firing

Several multi-pellet munitions were fired using the skip fire method. From a limited number of tests, it appears that skip firing focuses the pellets on the target with little or no loss in imparted momentum as compared to direct fire shots.

The attributes presented in this report need to be used with caution. The accuracy and imparted momentum data were obtained using only five rounds of each munition type. As discussed in the *Observations and Recommendations* section, it is strongly recommended that further tests be conducted using larger sample sizes. Furthermore, the momentum data is the momentum that was imparted to the ballistic pendulum. No attempt has been made to translate those momentums to the momentum that would be imparted to the human body. Nor has any attempt been made to relate the amount of imparted momentum to the probability of injury.

The Los Angeles County Sheriff's Department and the Institute for Emerging Defense Technologies, through the Applied Research Lab/Penn State University, do not endorse any specific product that was tested during the course of this study or is mentioned in this report. The Attribute-Based Evaluation (ABE) is not intended to indicate measures of effectiveness, make assumptions about minimum and maximum ranges, identify potential injury, or make any recommendations as to which brand is more suited for a given purpose. Nevertheless, this study is intended to provide critical data in a usable and understandable format to allow law enforcement and military personnel to reasonably compare like information and make an informed decision on the suitability of a particular munition for a given purpose.

The data can be found in the appendices of this report. This report and the data will be made available to the public via a website:
www.arl.psu.edu/areas/defensetech/defensetech.html

Introduction

Background

Since 1995, a class of less-than-lethal munitions commonly called “extended-range, impact munitions” has dominated the less-than-lethal field in both law enforcement functions and military peacekeeping applications. These munitions comprise a variety of projectiles ranging from lead-filled pads to plastic fin-stabilized projectiles to rubber pellets and others. Regardless of the projectile configuration of these munitions, almost all of them work by striking a target with sufficient force to cause compliance through the application of pain. Over time, scores of lives have been saved because these munitions offer an alternative option in those situations that have previously required deadly force.

In attempts to find alternatives to deadly force for safely controlling non-compliant and often violent individuals, the Los Angeles Sheriff’s Department has been long recognized as a leader in the identification, development and integration of less-than-lethal alternatives. They have enjoyed tremendous success and gained worldwide recognition for resourceful and imaginative less-than-lethal projects and have provided guidance and assistance to the U.S. military, as well as other law enforcement agencies throughout the United States and abroad.

The Pennsylvania State University’s Institute for Emerging Defense Technologies is also a leader in the less-than-lethal and non-lethal weapon community. The Human Effects Advisory Panel (HEAP), which is part of the Institute, conducted the first assessment of the human effects of extended-range impact munitions. Furthermore, the Institute conducts less-than-lethal research related to exploring the needs of the military and law enforcement in the development of non-lethal solutions and conducts non-lethal weapon education programs.

As more varieties of these less-than-lethal munitions became available, it became more difficult for the users to make intelligent and informed selection decisions. Critical factors such as ballistic stability, energy transfer, price, range, and accuracy varied among the many munitions. Further complicating this problem was the fact that the munitions are very dissimilar and standards for one type of munition would not be applicable to another. In fact, some devices defied comparison such as the beanbag versus the “hybrid” Pepperball™, which are functionally different. Furthermore, the state of the art continues to advance rapidly and the establishment of any standards could hinder the development of innovative new munitions by requiring conformity.

This problem was first recognized in late 1996 and the Los Angeles Sheriff’s Department (LASD) began campaigning for objective and measurable criteria to identify the best munition for a given situation. The LASD suggested a simple solution to a complex problem. Rather than attempt to establish standards, they recommended listing the common characteristics of each munition as provided by developers and measuring the common critical factors such as accuracy and energy transfer. This approach would provide important attributes about these types of less-than-lethal munitions to the users, the military and law enforcement communities, and allow them to make informed decisions that matched their specific needs.

Working together since 1997, the Los Angeles Sheriff's Department and Penn State's Institute for Emerging Defense Technologies decided to tackle this problem in a preliminary way in order to provide a starting point. Penn State's Applied Research Laboratory provided some funding, manufacturers donated the munitions, and both Penn State and LASD donated people, time and equipment. The result of this collaboration is the Attribute-Based Evaluation (ABE) Report.

The Attribute-Based Evaluation (ABE) of extended-range impact munitions was conducted to provide law enforcement and the military with an unbiased objective comparison of available less-than-lethal munitions. The objectives of this study are to provide easily accessible and readily understandable reference information, which does not currently exist in a "single-source" and is immediately useful for law enforcement and the military. Until this time, the only data available on the various products was that provided solely by a vendor. Comparisons and claims such as, "similar to being hit by a baseball," had to be assumed as accurate. In some cases, only favorable information was provided. Hence, while accurate, the information necessary to make an informed decision for a particular munition was incomplete.

The Attribute-Based Evaluation was designed to provide information on operational practices in a field setting rather than a pure scientific experiment. Consequently, some compromises were inevitable. For example, munitions were launched from a freestanding (offhand) position as they would be most likely be used in the field, rather than from a bench rest. Likewise, while many manufacturers and developers provide minimum and maximum effective ranges, they have evolved from laboratory settings and have no real tactical significance. The ranges used for this study were based upon field requirements as specified by LASD and not manufacturer specifications.

Significance

There is a recognized need among law enforcement agencies and organizations across the United States for a broadly scoped assessment of the less-than-lethal munitions currently available from commercial sources. When local police and military departments consider the procurement of these specialized munitions, there are only the manufacturer's available specifications and performance characteristics upon which to base a decision "to buy or not to buy." This initiative, co-sponsored by the Los Angeles Sheriff's Department and Penn State University and endorsed by The Pennsylvania State Police, is a quick-look, or preliminary, evaluation of off-the-shelf less-than-lethal munitions that will allow law enforcement officials a comparative basis for determining what munition is best suited to meet their requirements.

The evaluation was conducted over a two-day period in the Los Angeles area. 80 less-than-lethal munition types were donated by various manufacturers and fired at a ballistic impact measurement device (pendulum plate) by LASD marksmen. A team of professionals from LASD and Penn State University characterized the munitions. All of the team members had significant less-than-lethal weapon experience. The munitions were assessed for accuracy and impact force.

This report and the data will be made available to public via a website:
www.arl.psu.edu/areas/defensetech/defensetech.html

Team members

The partnership created to complete the ABE is comprised of law enforcement, academia, and industry, and illustrates the mutual desire for cooperation. The three authors of this report are:

Dr. John M. Kenny

Dr. Kenny is an associate research engineer at Penn State's Applied Research Laboratory. As the principal investigator for the Human Effects Advisory Panel (HEAP), he has expertise in the area of the human effects of less lethal, extended-range impact weapons. He was a fellow at the Brookings Institute and is a retired U. S. Navy Commander who commanded two ships. He is the principal investigator and test director for this project.

Captain Sid Heal

Captain Heal is a 26-year veteran with the Los Angeles County Sheriff's Department and is presently in command of LASD's Special Enforcement Bureau. He is nationally recognized as a less-than-lethal weapon expert and has extensive experience in the use of less-than-lethal munitions. He is a Chief Warrant Officer 5 in the U. S. Marine Corps Reserve and has participated in peacekeeping missions in Somalia and Bosnia.

Captain Michael Grossman

Captain Grossman is a 28-year veteran with the Los Angeles County Sheriff's Department. He commands LASD's Emergency Operations Bureau. He recently served in a two-year assignment with the National Institute of Justice in Washington D.C., as the Director of the Technology Assistance Division. He is a court-recognized expert in use of force, and has an extensive background in field operations, custody, court services and administrative assignments.

Figure 1.

Captain Mike Grossman and Captain Sid Heal inspect the less-than-lethal launchers.

It is with a great deal of pride and gratitude that the authors of this report recognize the contributions of Penn State University, the Los Angeles Sheriff's Department and the manufacturers of the donated less-than-lethal munitions. A complete list of participating personnel and manufacturers can be found in Appendix A.

Los Angeles Sheriff's Department

The LASD effort, under the direction of Chief Ken Bayless, provided manpower and equipment. The LASD collected and inventoried the munitions. The Department provided marksmen from two Special Weapons Teams. The marksmen and their qualifications are discussed in the *Qualification of Shooters* section. The Department also provided all of the launchers and a high-speed camera, which was used to record the test events.

The Pennsylvania State University's Applied Research Lab

Penn State's Applied Research Laboratory (ARL), under the direction of Dr. L. Raymond Hettche, provided funding, manpower and equipment. The funds were used to purchase the use of SARA's ballistic pendulum. Dr. John Leathers, Dr. Nick Nicholas, and Mr. Mike Coslo assisted with the data collection effort.

Limitations

This study provides a vast amount of information on a number of less-than-lethal munitions that (1) are launched, (2) have an effect beyond the muzzle (extended-range), (3) are intended to be less-than-lethal, and (4) rely on an impact for effectiveness (except for some hybrids such as pepperballs). Consequently, there are a number of other commercially available less-than-lethal options such as riot control agents, non-lethal grenades, olfactory agents, and Tasers™ that were not tested. Moreover, because this study only examined munitions that were commercially available or available within the next two years. Users and decision-makers should be aware that there are other less-than-lethal options beyond those discussed in this report.

The data is provided so that the user can make better decisions about various types of less-than-lethal, extended-range impact munitions.

How to use the data

The data is provided so that the user can make better decisions about various types of less-than-lethal, extended-range impact munitions. The attributes are not listed in any order of priority. The user must make those decisions about priority. Once those decisions are made, the data can be sorted accordingly. Examples of this approach are presented on page 39 of this report.

Limitations of data

The attributes presented in this report need to be used with caution. The accuracy and imparted momentum data were obtained using only five rounds of each munition type. This is a very small sample size. As discussed in the *Observations and Recommendations* section, it is strongly recommended that further tests be conducted using larger sample sizes. Furthermore, the momentum data is the momentum that was imparted to the ballistic pendulum. No attempt has been made to translate those momentums to the momentum that would be imparted to the human body—although those momentums are related, nor has any attempt been made to relate the amount of imparted momentum to the probability of injury.

Notice of non-endorsement

The Los Angeles County Sheriff's Department and the Institute for Emerging Defense Technologies, through Penn State's Applied Research Lab, do not endorse any specific product that was tested during the course of this study or is mentioned in this report. The Attribute-Based Evaluation (ABE) is not intended to indicate measures of effectiveness, make assumptions about minimum and maximum ranges, identify potential injury, or make any recommendations as to which brand is more suited for a given purpose. Nevertheless, this study is intended to provide critical data in a usable and understandable format to allow law enforcement and military personnel to reasonably compare like information and make an informed decision on the suitability of a particular munition for a given purpose.

The Attribute-Based Evaluation (ABE) is not intended to indicate measures of effectiveness, make assumptions about minimum and maximum ranges, identify potential injury, or make any recommendations as to which brand is more suited for a given purpose.

Press interest

This study has attracted substantial media attention and was covered by the local CBS affiliate with a short segment on the local news, and ABC Los Angeles featured a five-minute segment during prime time news. The Los Angeles Sheriff's Department is also making a documentary of the study that will be available for distribution contemporaneous with this report. In addition, numerous interested parties have made formal requests for the report from six different countries. It has always been the intent of both the Los Angeles Sheriff's Department and the Institute for Emerging Defense Technologies to make this information available to the widest possible audience. Consequently, the complete version of the study will be made available to interested parties via the World Wide Web (www.arl.psu.edu/areas/defensetech/defensetech.html), and through articles in various professional publications.

Figure 2.

The ABC Los Angeles affiliate Channel 7 observed the tests. A five-minute segment on the ABE tests was broadcast during the prime time news. Here, an ABC reporter interviews Dr. Kenny.

Legal interest

One of the most basic tenets of law is that people are responsible for the reasonable consequences of their actions. The understanding and application of this doctrine is always critical but never more important than when applying force. For years, military and law enforcement agencies have earnestly sought reliable guidelines for choosing and employing minimal force options, particularly less lethal, extended-range impact munitions.

In attempting to develop safe and effective minimal force options, the scientific breakthroughs have been sporadic, unpredictable and taken on a variety of forms. Development of meaningful and reliable standards has been especially difficult and complicated in that many devices and munitions are so dissimilar that standards developed for one type or class can be completely irrelevant for another. Despite the best efforts of the developers, manufacturers, law enforcement and military agencies, no reliable standards currently exist for evaluating critical factors such as accuracy, range, anticipated effects and other critical factors.

…this …study attempts to identify practical and reliable criteria…

Without creating standards, this first-of-its-kind study attempts to identify practical and reliable criteria that practitioners can use to make decisions on which style, type, class, brand, caliber, or other criteria will best suit their particular purposes. It goes a long way in leveling the playing field by identifying criteria from the field rather than the laboratory and is a first step from which meaningful standards can eventually evolve.

Extended-Range Impact Munitions and Launchers

Launched, extended-range, impact munitions

Launched, extended-range, impact munitions comprise the “bread and butter” of law enforcement less-than-lethal options. In order to qualify for the study, a munition was required to meet three standards. First, it must use some type of launcher (i.e., 12-gauge shotgun). Munitions such as flashbangs, stingballs, and the like could be launched but are more commonly deployed as hand-thrown devices and thus, were not addressed in this study. Second, while some munitions are effective at the muzzle, they were also required to be effective beyond the muzzle to meet the criteria for this study. Third, an impact was required for the munition to be effective. While many of these munitions are designed to strike people, some, such as the “Pepperball™” and “bladder bullets” might be equally effective striking near an adversary and releasing a marker, dye, malodorant, or riot control agent.

While these munitions take on a variety of forms, their single distinguishing feature is that they are all projectiles of some sort. They are launched from a variety of devices including grenade and tear gas launchers, shotguns or attachable launchers to military weapons. They rely on impact to be effective.

Some munitions had very similar attributes and, in those cases, only a representative sample was fired. For example, given two identical munitions, one designed to be fired from a 37mm launcher and the other from a 40mm launcher, only one type was tested.

Description of ammo types

In all, 80 different varieties were actually measured. These were divided into seven classes. Each of these classes is defined and described as follows:

Airfoil

An airfoil is a projectile designed and launched in such a manner as to provide stability, direction and lift while in flight. Developed by Edgewood Arsenal in Maryland in the late 1960s and early 1970s, this projectile is a cylindrically shaped airfoil that provides lift after launching. It is approximately 64mm in diameter with the leading edge rounded and then tapering back to a thin trailing edge in the same shape as the wing of an aircraft. This allows the projectile to fly to its target and is meant to diminish the effects of trajectory degradation common to other types of projectiles. The Ring Airfoil Projectile (RAP) attaches to an M16A1 or AR15 A1 rifle, a special blank firing cartridge and the rubber ring airfoil projectile. Besides being one of the very few projectiles believed to be non-lethal at the muzzle, the peripheral edge of the projectile on the outside of the cylinder has compartments for holding a chemical agent during flight and then dispersing it upon impact. These projectiles are to be fired directly at an adversary. Currently, there is only one airfoil projectile known. See Figure 3.

Figure 3.

The Ring Airfoil Projectile.

Baton: foam, plastic, rubber, styrofoam, or wooden

A baton is a projectile constructed of short, thick material and relies on extended-range impact for effectiveness. These munitions come in two distinct styles. The first employs a single projectile most commonly launched from either tear gas or grenade launchers. The projectile is approximately four inches long with a large extended-range end approximately one and one-half inches in diameter for about two inches and then dropping in diameter sharply to a “tail” of about three inches long and one-inch in diameter. The projectiles are designed to maximize ballistic stability and are either rubber, Styrofoam or plastic and are direct fired only.

The second style uses three or five cylinder-shaped projectiles also most commonly launched from either tear gas or grenade launchers. Each cylinder is approximately 1.5 inches in diameter by about 1 inch long of foam, plastic, rubber or wood. Those designed to be launched from shotguns are about 0.625 inch in diameter by about 1 inch long. This style can be direct or skip fired. Wooden batons are skip fired only because of the danger of inflicting serious or fatal injury. Most of these munitions are launched from tear gas or grenade launchers. Consequently, the greatest variety of cartridges are available in 37/40mm configurations, in lengths ranging from 5 to 8 inches. Some wooden baton varieties are available for 12-gauge shotguns.

Drag-stabilized

Some projectiles employ a flexible tail to provide stability while in flight. These projectiles are drag-stabilized and are equipped with a flexible tail to improve ballistic stability and prevent the tumbling and sailing effect. This projectile commonly employs an open-ended, single fabric container filled with lead shot that is tied, sewed or crimped to seal the shot in one end. The remainder of the material is either left loose or cut into individual tails that trail and stabilize the projectile while in flight. One version employs a conventional pad round with a thin fabric tail sewn on one side. The most distinguishing feature of these type rounds is their distinctive tails. These vary in length from about one inch to several inches. Because most of these munitions employ a single fabric container that resembles a stocking or sock, they are often referred to as “sock rounds.” All drag-stabilized projectiles are designed to be fired directly at an adversary’s center of mass.

Encapsulated

Any projectile that encloses a liquid, powder or other material with a membrane, protective coating or shell, and disperses the agent upon impact is known as an encapsulated projectile. These types of projectiles are among the most recent innovations in less-than-lethal munitions. They are distinguished from some older and more conventional chemical agent munitions in that they are capable of striking a person without causing serious injury. In fact, some strike only hard enough to release an agent and would not otherwise qualify as an impact munition when compared to the conventional baton or pellet rounds.

Some encapsulated rounds are intended to cause pain, but are designed to release excess energy by bursting which prevents penetration into the body. Others are a hybrid, in that they are both an impact munition and a chemical delivery device. Encapsulated rounds are usually fired directly at an adversary. However, those that employ a chemical agent may be just as effective when striking a hard object in close proximity to an adversary. The distinguishing feature for all encapsulated projectiles is the frangible nature of the projectile itself.

Fin-stabilized

Fin-stabilized projectiles employ rigid or semi-rigid vanes or fins to steer, stabilize, or balance the projectile. The front portion of these projectiles is cylindrical in shape with either a flat or blunt nose. The rear of the projectile has two or more rigid vanes or fins designed to keep the projectile straight and true in flight. Figure 4 is a photograph of fin-stabilized projectiles. Typically, these projectiles use four or more fins of the same material and diameter as the front of the projectile. The characteristic rigid or semi-rigid fins at the rear of the projectile easily identify these munitions. The fins may extend from the front portion of the projectile or be separated with a space between the front of the projectile and the rear stabilizing fins. Some developers are exploring foldable fins that open in flight to provide greater stability after the projectile is released from the confines of the shell casing and/or launching tube, but are still in the developmental stage and are not currently available. Fin-stabilized projectiles are direct fired at an adversary.

Figure 4.

Fin-stabilized projectiles. The projectile on the left is a 37mm projectile and the three on the right are 12-gauge projectiles of various tail configurations.

Pads: rectangle and round

Projectiles that employ a pouch containing a heavier material are known as pad projectiles. These projectiles are among the oldest and most well known of the less-than-lethal extended-range impact munitions. The pouches are commonly made of ballistic nylon or similar high-strength, resilient material with silica, lead, or steel shot sewn inside. The pads may be round, rectangular, or square and are folded longitudinally inside a shell casing. After launching the pads are intended to open in flight and strike an adversary with one of the large flat sides. These munitions are available for both shotguns and teargas or grenade launchers. Some projectiles of this variety are saturated with a colored dust or chemical agent to aid in identifying an adversary. After firing, one side is often heavily stained with residue from the barrel. These projectiles are direct fired at an adversary.

Pellets: single, multiple large, and multiple small

These munitions employ one or more spherical projectiles that rely solely on extended-range impact for effectiveness. They are categorized as either single or multiple spherical projectiles. The single projectile variety varies in size from about .68 caliber to well over 1 inch in diameter. The multiple projectile variety employs multiple small shot-like pellets similar to the lethal buckshot counterpart. Depending upon the brand and model, pellets vary in diameter from about 0.25 inch to over 0.5 inch. Firing directly at an adversary most commonly employs the single projectile munitions, while the multiple pellet rounds can be fired either directly (see Figure 5) or by skipping them off a hard surface immediately in front of one or more adversaries. These projectiles are most commonly manufactured from rubber or PVC of varying degrees of hardness and come in a variety of sizes and hardness. They can be launched from shotguns and teargas or grenade launchers.

Figure 5.

Small pellets just prior to impacting the ballistic pendulum.

Manufacturers

The manufacturers, developers, and vendors donated all munitions used in this study. Were it not for their generosity, this study would not have been possible. The estimated value of the donated ammunition was approximately $20,000**.** In addition to providing the wide variety of less-than-lethal munitions, several of the manufacturers were present during the testing. The following manufacturers provided munitions for this study:

- ALS Technologies
- Combined Tactical Systems
- Defense Technologies
- Edgewood Arsenal & Guilford Engineering, Inc.
- Jaycor
- MK Ballistics Systems
- Royal Arms International
- Sage, Inc.
- Technical Solutions

A complete identification list of the manufacturers can be found in *Appendix B*.

Launchers

The launchers chosen for the test are those commonly found in the armories of law enforcement agencies throughout the United States, primarily the shotguns and teargas launchers. Within the American law enforcement community, it is customary to refer to shotguns and teargas launchers used to launch less-than-lethal munitions as “launchers” rather than guns or weapons. Each of the launchers was measured at the muzzle to the nearest one-hundredth of an inch and labeled. The launchers were cleaned periodically throughout the firing phase of the evaluation to attenuate fouling problems.

Each munition was tested using the specific launcher requested by the manufacturers and developers. This was done so that the best performance would be observed during the tests. For example, the Defense Technologies X1006 Exact Impact munition requires a 40mm launcher with a rifled bore.

The launcher used with each munition type is listed in the appendices.

The Measured Attributes

Data on 17 different attributes were collected on each munition type. These attributes are listed below and the related information defines the attribute, explains the relevance of the attribute and describes the data collection method. The results of the data collection effort are contained in the *Findings* section and a complete list of the attributes is found in the appendices. Each munition type has been assigned an identification number.

. . . 17 different attributes were collected on each munition type.

Manufacturer

This attribute is the name of the manufacturer or developer and includes all available contact information such as address, telephone number, fax number, e-mail address, and web address. This data was collected to enable the user to contact the manufacturer and obtain further information regarding a specific munition and/or for purchase. The information was gathered from catalogs, web sites, brochures, or other advertisements.

Model

This attribute lists the model name and number or nomenclature provided by the manufacturer or developer to precisely identify a specific munition. As users of extended-range impact munitions know, some of these munitions are often designated by alphanumeric code and/or share common names with other brands. Each munition was precisely identified with the specific name and/or number used for ordering. Whenever possible, this information was obtained directly from the manufacturer or developer. Other methods included invoice, packing slip, catalogs, specification sheets, web site, brochures, or advertisements.

Retail price

This attribute lists the Manufacturer's Suggested Retail Price for a single projectile. Volume discounts were not considered. The prices listed were accurate at the time of the data collection effort (October 2000). However, the user should check with the manufacturer for the current price.

The price of a shotgun-launched extended-range, impact munition can exceed the price of its lethal counterpart by as much as ten times.

The price of a shotgun-launched extended-range impact munition can exceed the price of its lethal counterpart by as much as ten times. Furthermore, for every munition purchased for field use, four or five are purchased for training and qualification purposes. Consequently, the price of a particular munition can become a critical factor in the decision of which munition should be purchased and can be the deciding factor between two similar munitions. The prices were obtained from the manufacturers, developers, catalogs and brochures for the purchase of a single projectile.

Availability

This attribute distinguishes between munitions commercially available and those under development. Munitions are constantly being improved and new munitions are developed. Whether a munition is currently available or will be available in the near future will have an impact on a user's decision, not only on what to purchase but the quantity. For example, a user might purchase a small number of munitions as a near-term solution, with the intention of buying a larger number when an improved version becomes available. This information was obtained directly from the manufacturer, developer or published price lists and brochures. For purposes of this study, munitions not expected to be commercially available within 24 months were not considered.

Configuration

This attribute describes the physical make-up and shape of the projectile. In those munitions that used pellets, large pellets were defined as those that had a diameter of 0.5 inch or greater, and small pellets had diameters less than 0.5 inch. Less-than-lethal, extended-range impact munitions come in a variety of configurations, each attempting to provide some specific advantage. Figure 6 is an example of the variety of munitions currently available. Users can use the configuration for a specific munition to determine the suitability of a particular munition for a given purpose. As an example, some munitions discriminate between individual targets (they are designed to strike a single individual at a given range) and others are area munitions (designed to impact more than one person in close proximity at a given range). This information was obtained directly from specification sheets and brochures provided by the manufacturers and developers.

Figure 6.

Various types of less-than-lethal, extended-range impact munitions. From the left, the munitions are 40mm, 37mm, and two 12-gauge munitions.

Cartridge size

This attribute contains the length of a cartridge. Some 37/40mm munitions come in 4-, 4.8-, 5-, and 8-inch lengths. Launchers for less-than-lethal munitions come in a variety of sizes, shapes, configurations and caliber. Many launchers were originally designed and intended for use as a lethal weapon launcher. Because the launcher can be the most expensive component of a less-than-lethal system, the purchase of munitions that can be launched from devices already in an arsenal can be a major factor in selecting munitions. This information was obtained directly from specification sheets and brochures provided by the manufacturers and developers.

Material

This attribute describes the primary material that is used to construct the projectile. Projectiles for less-than-lethal extended-range impact munitions come in a variety of materials, such as rubber, lead, steel, silica, and plastic. Figure 7 provides some examples of the materials used in the manufacture of these projectiles. Precise environmental and human effect data is seldom available for these munitions and, as a result, the composition of a projectile can become a factor for selection. It should be noted that only the predominant material was identified. Many munitions are composites, such as encapsulated and pad munitions. This information was obtained directly from specification sheets and brochures provided by the manufacturers and developers.

Figure 7.

Various materials used in the manufacture of extended-range impact projectiles. From the left, there is silica in a rectangular pad, lead shot in a round pad, a finned rubber projectile, and a foam batons.

Launcher

This attribute lists the launcher that must be used with each munition. Launchers for less-than-lethal extended-range impact munitions come in a variety of sizes, shapes and caliber. As was noted earlier, many were originally designed and intended for use as lethal munition launchers. Because the launcher can often be the most expensive component of a less-than-lethal system, the purchase of munitions that can be launched from devices already in an arsenal can be a major factor in selecting munitions. This information was obtained directly from specification sheets and brochures provided by the manufacturers and developers.

Method of engagement

This attribute identifies the primary method of engagement as recommended by the manufacturer. Some munitions, such as wooden baton rounds, should be skip-fired. Others, such as rubber or foam baton rounds, drag-stabilized or fin-stabilized projectiles are more effective when fired directly at a target. Still others, especially multiple-pellet munitions can be either skip fired or direct fired. How a munition will be used may be one of the key selection factors. This information was obtained directly from specification sheets and brochures provided by the manufacturers and developers. It should be noted that those munitions designed to be only skip fired were not tested. Although there were a few tests of skip fired munitions, most of the test data that is presented in this report are for munitions that were fired directly at the ballistic pendulum.

Field identification

This attribute lists the primary method by which a munition is distinguished from other munitions, both lethal and less-than-lethal. This information is important because many of these munitions are launched from existing launching devices and they look identical to their lethal counterpart. Furthermore, different configurations for less-than-lethal munitions, especially those made by the same company, are usually distinguished from each other using only the model numbers or information labels on the sides of the canisters. In field applications, this can become troublesome, especially in low-light conditions or when labels are obscured or obliterated from handling. Figure 8 provides an example of some of the methods used to identify these types of munitions. Some manufacturers have attempted to assist in identifying particular munitions by using color, shape, tactile identification (bumps, raised letters, etc.) and other methods. This information was obtained directly from specification sheets and brochures provided by the manufacturers and developers and verified by personal observation.

Figure 8.

Various types of field identification of less-than-lethal, extended-range impact munitions. From the left, 37/40mm projectile that uses writing, a 40mm sponge grenade that can be identified tactilely, and a 12-gauge round with a clear casing that can be identified visually.

Number of projectiles

This attribute provides the number of projectiles contained in each less-than-lethal, extended-range impact round. The number of projectiles in a single round often determines whether a munition is intended for use against a single target or as an area munition. This attribute provides strong clues for such decisions as the appropriateness of a munition for an intended purpose, how it should be employed, the likelihood of collateral damage, and so forth. This information was obtained directly from specification sheets and brochures provided by the manufacturers and developers.

Special features

This attribute identifies any special features for a particular munition. As less-than-lethal munitions continue to be improved, some manufacturers and developers have provided additional features to enhance the use of a particular munition. For instance, some munitions contain dye-markers or colored-dust for "tagging" suspects (see Figure 9) for later arrest or are "liquid-filled" so that chemical agents can be employed, and so forth. This information was obtained directly from specification sheets and brochures provided by the manufacturers and developers.

Figure 9.

An example of an extended range munition that uses colored dust to tag individuals.

Accuracy at 21 feet

This attribute measured the degree of precision that a given munition could reliably strike a target at a given range. The ability to strike a target with any less-than-lethal projectile is a critical factor for selecting and employing a particular munition. Because no official criteria have previously existed, one standard that has been used in the past has been a percentage score that a particular less-than-lethal munition could hit a "man-sized" target at a given range. Where it hit the target was of little consequence, since by definition, *any* hit met the standard. Even this standard has been difficult to measure at ranges beyond 75 feet and scores were typically in the 80th percentile range. In actual field situations these criteria are unacceptable in that strikes to vulnerable parts of the body, especially the head and neck, can cause serious injury or death with some munitions.

At present, less-than-lethal munitions do not approach the accuracy demanded of their lethal counterparts. A more realistic attribute is the amount of dispersion of each munition at a given range. The concept behind this approach is that the smaller the amount of dispersion the higher degree of confidence of being able to hit where aimed. Higher accuracy reduces the likelihood of unintended consequences.

…less-than-lethal munitions do not approach the accuracy demanded of their lethal counterparts.

Accuracy is a function of range and recommended ranges for less-than-lethal, extended-range impact munitions have been entirely at a manufacturer's or developer's discretion. Manufacturers provided ranges where a given munition would be effective without resulting in serious injury or death. Each manufacturer and developer provided their own estimation and some, for civil liability reasons, provided none at all. The ranges varied, not only from manufacturer to manufacturer, but also from munition to munition. Moreover, these recommended ranges had no tactical significance. They were simply estimations designed to provide guidance for the employment of a given munition, usually under ideal conditions. This has resulted not only in an inability to reliably compare one munition with another but a lack of meaningful criteria to determine suitability in field employment.

Twenty-one feet was selected as the short range distance and is generally considered to be the distance at which an adversary, armed with an edged-weapon or club, can close before an officer can defensively respond. This range of 21 feet has particular significance in the selection of less-than-lethal options because a law enforcement officer approaching an adversary at a distance of less than 21 feet or closer accepts the risk of being killed if the less-than-lethal option is not immediately effective.

Twenty-one feet… is generally considered to be the distance at which an adversary, armed with an edged-weapon or club, can close before an officer can defensively respond.

Five rounds for each type of munition were fired at the ballistic pendulum at the given ranges. The impact plate was covered with paper with a "bulls-eye" target centered on the impact plate and used for point of aim. The diameter of the "bulls eye" target was 5.5 inches. This included the "X" ring, the 10 ring and the 9 ring, which is standard for bulls eye targets. Accuracy was determined to be the smallest diameter circle that would enclose all five impacts, and not "point-of-aim, point-of-impact." Thus, neither the "sighting in" of a launcher for each munition nor the use of different launchers for different munitions was a factor.

Accuracy at 75 feet

This attribute measured the accuracy of less-than-lethal, extended-range impact munitions at a range of 75 feet. The minimum "far range" desired for the effective employment range for less-than-lethal munitions is sixty-yards or greater. This is generally considered to be the distance at which a person can throw an object large enough to cause serious injury. This distance is based upon a study conducted by the LASD in December 2000. See Figure 10. The study used young, healthy adult males (police academy recruits) throwing a variety of objects commonly used as missiles during riots. Those objects included bricks, portions of bricks, bottles and rocks. This study revealed that less than 3% of the test population was capable of throwing an object greater than 530 grams (1.2 lbs.) further than 180 feet. Some small, hard objects, such as golf balls, spark plugs, and lead wheel weights, (commonly hurled by rioters) require even greater ranges. Nevertheless, few launchable, extended-range impact munitions are capable of reliably striking a man-sized target at these ranges. Consequently, a compromise range of 75 feet was selected until the state of the art advances to provide the desired tactical advantage.

…less than 3% of the test population was capable of throwing an object greater than 530 grams (1.2 lbs.) further than 180 feet.

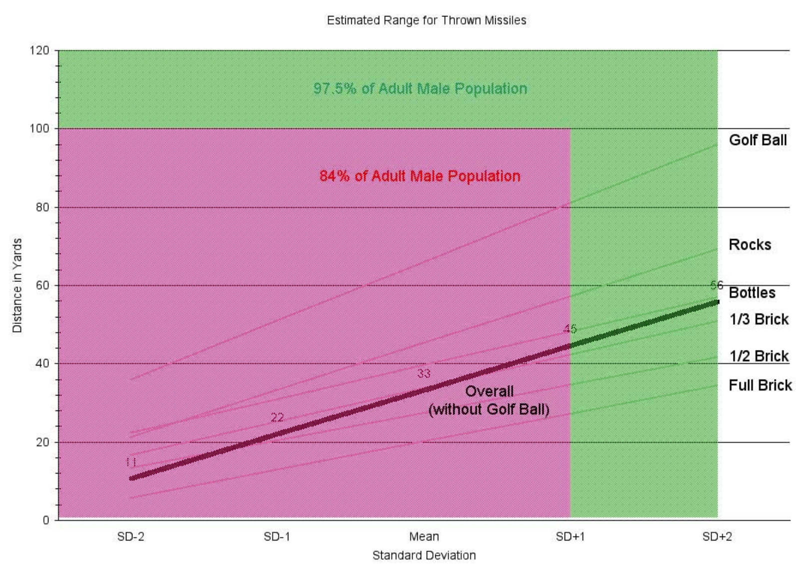

Figure 10. This graph displays the results of a test conducted by the LASD to determine the maximum distances that various objects could be thrown by young healthy males.

The measurement techniques were identical to those used at a range of 21 feet. Five rounds for each type of munition were fired at the ballistic pendulum at the given ranges. The impact plate was covered with paper with the "bulls-eye" target centered on the impact plate and used for point of aim. Accuracy was determined to be the smallest diameter circle that would enclose all five impacts, and not "point-of-aim, point-of-impact."

Momentum

The momentum of an object is equal to its mass multiplied by its velocity. Momentum is measured in kilogram-meters per second ($kgms^{-1}$), which is also known as a Newton-second. Momentum is expressed in the equation $p=mv$, where p is the momentum, m is the mass and v is the velocity.

In the game of football, a running player has momentum. For example, a running back that weighs 95.45kg (210 lbs.) and runs at a speed of 10 meters per second (22 mph) has a momentum of 954.5 $kgms^{-1}$. Players of different weights running at the same speed have different momentums. The momentum increases with increases in the mass and velocity.

Unless an outside force acts on the running player, he will continue to move at his present momentum (speed and direction). Stopping his momentum will require force over time. To stop this player or change his momentum, a tackler would have to apply a momentum (also called an impulse) in the opposite direction. Impulse is the product of the applied force and the time over which that force is applied. To stop the runner, the tackler would have to apply an impulse of 954.5 $kgms^{-1}$.

In any collision (or tackle) in which there is no force other than that created by the collision itself, the total momentum of those involved must be the same before and after the collision. This concept is known as the conservation of momentum. To continue this example, the running player collides with the goal post. The player and goal post do not remain in contact after the collision and this is known as an elastic collision. At collision, some of the momentum is transferred to the goalpost, some is lost to forces such as compression and deformation, and some remains with the player as he is knocked backwards.

In the tests conducted for this report, the less lethal, extended-range impact projectile is like the running player. It has a momentum composed of its mass multiplied by its velocity. The ballistic pendulum is like the goal post. The momentum measured during these tests was the momentum transferred to the ballistic pendulum during the collision between the projectile and the plate. All of these collisions were elastic in that all of the projectiles bounced backwards off the plate, some more so than others.

The ballistic pendulum is not an accurate model of the human body. The momentum imparted from the projectile to the ballistic pendulum will not be the same momentum imparted to the human body from an identical projectile with an identical momentum.

The ballistic pendulum is not an accurate model of the human body. The momentum imparted from the projectile to the ballistic pendulum will not be the same momentum imparted to the human body from an identical projectile with an identical momentum. However, the imparted momentum measurements found in this report provide the reader with a relative sense of the momentum that is transferred to the target upon impact with a given projectile. As will be seen in the *Findings* section of this report, some of the projectiles have higher momentums than others, and these projectiles will transfer higher momentums to the target.

Imparted momentum at 21 feet

This attribute measured the amount of momentum imparted to the ballistic pendulum when it was struck by a less-than-lethal, extended-range impact munition at a range of 21 feet. The momentum was measured in Newton-seconds (Ns).

As is widely recognized, reliable human effect data are all but nonexistent for determining the amount of force required for an impact device to be effective. Furthermore, some munitions, such as some encapsulated projectiles, require only a minimal amount of force to be effective because the amount of force need be sufficient only to burst the projectile and allow the action of some other process, usually a chemical agent. Complicating the problem still further, momentum is a function of mass times velocity. As the range to the target increases, the velocity and imparted momentum decrease. This will obviously degrade the effectiveness of these munitions. By firing munitions at different ranges, the imparted momentums can be measured and compared

Five rounds for each type of munition were fired at an “impact plate” at the given ranges. The amount of momentum for each shot was measured. The mean was determined and is contained in the data.

Imparted momentum at 75 feet

This attribute measured the amount of momentum imparted to the ballistic pendulum when it was struck by a less-than-lethal, extended-range impact munition at 75 feet. Again, the reasoning for the selection of this distance can be found in the *Accuracy at 75 Feet* section.

Five rounds for each type of munition were fired at an “impact plate” at this range. The amount of momentum for each shot was measured. The mean was determined and is contained in the data.

Weight

This attribute measured the weight of the projectile(s) to the nearest tenth of a gram. Each munition was separated from its canister, wadding, and other components and weighed using a digital gram scale. If a munition employed more than one projectile, a projectile was weighed and the figure multiplied by the number of projectiles in the munition. This number of projectiles was obtained from the specification sheets provided by the manufacturer or developer.

Test Methodology

Test set-up

SARA pendulum

The measurement portion of the study was conducted at Scientific Applications Research Associates (SARA) Laboratory in Huntington Beach, California. SARA was subcontracted to provide the ballistic pendulum and associated equipment and technicians to collect the ballistic pendulum data.

The pendulum consists of a mass plate, 36" × 36", suspended by four parallel pivot arms as does the classical pendulum. The inverted pendulum and its pivot arms are mounted to a steel frame that rests on the ground (see Figure 11). A tensioned cable and load cell (force measurement) maintains the pendulum in a vertical position. The pendulum was statically and dynamically calibrated. As configured, the pendulum measures imparted momentum in Newton-seconds.

Figure 11.

The ballistic pendulum used to conduct the momentum and accuracy tests. Scientific Applications Research Associates (SARA) Laboratory developed this pendulum. SARA was subcontracted to provide this ballistic pendulum and associated equipment and technicians.

Calibration was performed by hanging static weights on a cable attached to the center of the force plate. The plate was looped over a pulley with weights pulling vertically. From this procedure, a reference value for the pendulum of 150 microvolts per pound of force was obtained.

Data collection description

The data collection procedures were straightforward. Prior to the commencement of the test all of the munitions had been inventoried and segregated. Each munition was assigned an identification number and all of the attributes except accuracy and imparted momentum were recorded on paper data sheets.

For each munition, a new paper target was placed on the pendulum. The launcher and five rounds of the munition were provided to the shooter. Appropriate range safety procedures were strictly observed. After each munition was fired, the imparted momentum was recorded and the pendulum was reset. The projectile impact was recorded by the high speed camera (see Figure 12). After the five rounds had been fired, the diameter of the dispersion was measured and recorded. The test set up can be seen in Figure 13.

All of the attribute data was then transferred to a spreadsheet database. The paper data sheets were kept as a back-up record. This procedure was repeated for each munition over the two-day test period. The test results are discussed in the following section and the data can be found in the appendices.

Qualification of shooters

Because the actual firing of these munitions was done under "field-like" conditions, the shooters were chosen from the most qualified in law enforcement. In this case, they were primarily chosen from the Special Enforcement Bureau of the Los Angeles Sheriff's Department. Selection for this particular assignment is highly competitive and members are selected from seasoned "street cops" and only after thorough and rigorous testing. Furthermore, they are continually required to demonstrate proficiency throughout their tenure and are among the most highly trained SWAT officers in the United States.

Members of the Special Enforcement Bureau have been pioneers in developing minimal force options and have actively employed extended-range impact munitions since the early 1980s and, as the years have passed, have been instrumental in developing newer and better munitions. Many are certified instructors in less lethal options and several have gained a national reputation. They are not only thoroughly familiar with the munitions but with the launchers and characteristics of employment as well.

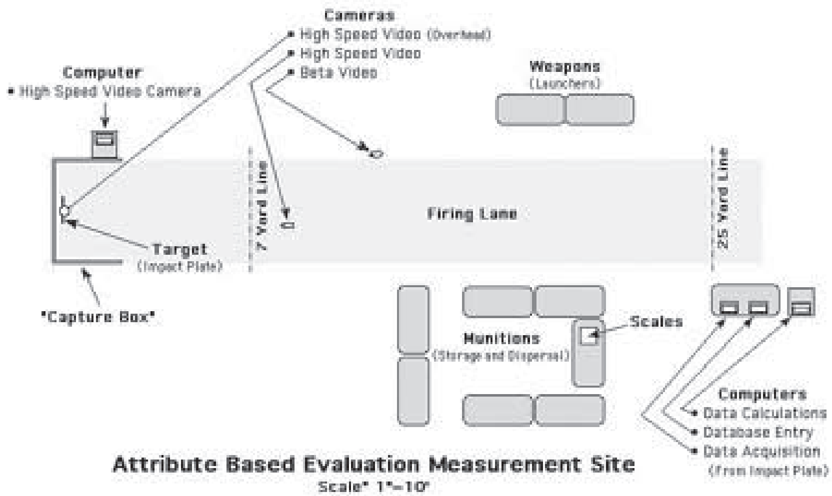

Figure 13. A diagram of the test site for the Attribute-Based Evaluation. Two high-speed cameras recorded the tests. One camera was located behind the shooter. The other camera was located directly above the ballistic pendulum and recorded the impact of the projectile on the plate.

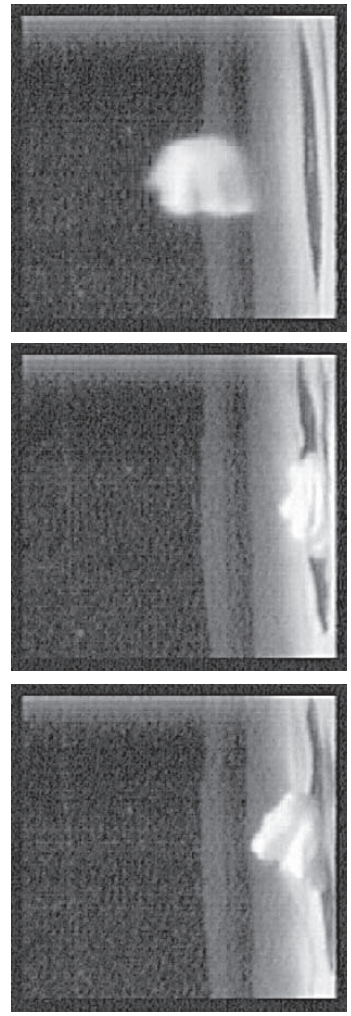

Figure 12.

High-speed photographic series of projectile impacting and rebounding off the surface of the ballistic pendulum.

Figure 14.

LASD Special Weapons Team member prepares to test fire a 40mm sponge grenade.

Findings

In this section of the report, each of the attributes are discussed and presented in graphic and tabular form.

Accuracy range 1 (21 feet)

Accuracy is the degree of precision that a given munition can reliably strike a target at a given range and should be a critical factor for selecting and employing a particular munition. The criterion selected to measure accuracy was the amount of dispersion a munition can be expected to deviate at a given range. The accuracy is expressed in inches and indicates the diameter of the dispersion for five rounds.

. . . there is a large range of dispersions regardless of the launcher selected, . . .

There are several interesting ways to examine the accuracy data. The first is to examine all of the data broken down by launcher type. This data is shown in Figure 15. As can be seen, there is a large range of dispersions regardless of the launcher selected, although the shotgun is more accurate than the 37mm or 40mm launcher at the range of 21 feet. It should be noted that even at the short range of 21 feet from the shooter to the target, there were dispersions that approached diameters of four feet.

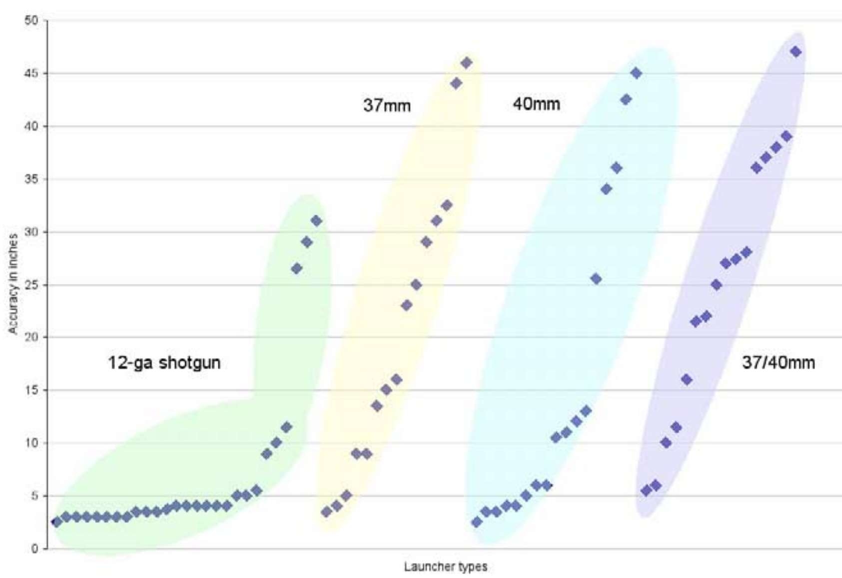

Figure 15. Accuracy of various launchers at a range of 21 feet. Accuracy is measured in inches and is the diameter of the dispersion of five rounds.

The accuracy data can also be examined using the configuration of the projectile as a variable. This is shown in Figure 16. Not surprisingly, it can be seen that there is a large range of dispersions for the pelleted munitions, which are meant to be area weapons. It was interesting to note that some munition configurations were more accurate than others and had consistently similar dispersion diameters despite the fact that the munitions were produced by different manufacturers. This can be seen for the rectangular pad and drag-stabilized projectile configurations.

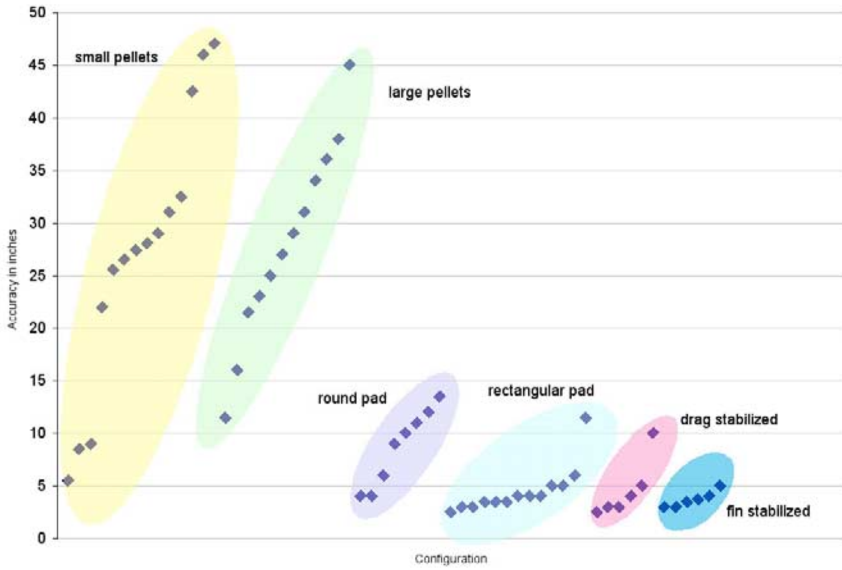

Figure 16. Accuracy of various configuration types measured at 21 feet.

The accuracy data was examined using the projectile materials as a variable. The results are shown in Figure 17. The projectiles are made out of several materials, but the two predominant materials are rubber and lead. The rubber projectiles, depending on their configuration, spanned the dispersion range. However, projectiles that used lead were shown to be very accurate with little variation of dispersions (as compared to rubber) regardless of the configuration.

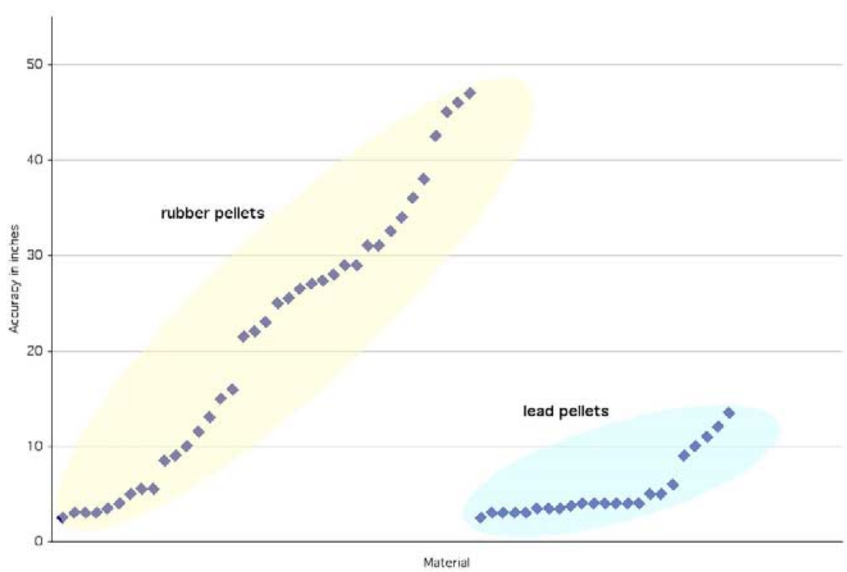

Figure 17. Accuracy of various materials at a range of 21 feet.

As can be readily seen, the accuracy of any of the munitions can be examined using any or several of the attributes as variables. One final example is given here. In this case, accuracy is examined for only the 12-gauge shotgun launcher using the projectile configuration as the examined variable. The purpose of such an examination would be to look for configuration types that are consistently accurate. This can be seen in Figure 18. The data for the rectangular pad projectiles and drag-stabilized projectiles have been highlighted as an example of fairly consistent accuracy. Both of these projectile configurations are available from several manufacturers. In that case the deciding criteria for the user might be ease of identification in the field or cost.

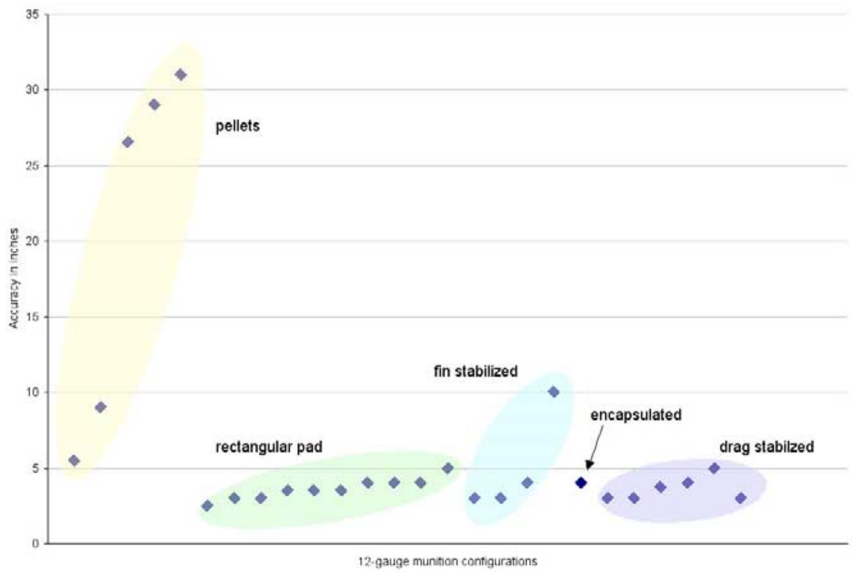

Figure 18. Accuracy of the 12-gauge shotgun launcher for various projectile configurations.

Accuracy range 2 (75 feet)

Thirty seven extended-range impact munitions were fired at a range of 75 feet. Of those 37 munitions:

- 17 had an accuracy dispersion of 18 inches or less (46%).
- 11 had a dispersion greater than 18 inches but equal to or less than 36 inches (30%).
- 9 could not reliably hit the impact plate (24% overall).

The 18 inches distance is an "average" man across the front or back between the armpits.

It is interesting to note that of these nine munitions, all of them had small dispersions at the 21-foot range and that the predominant configuration was the pad. Although the data set is very small, a conclusion might be drawn that the pad configuration may have a tendency to "sail" at longer ranges and become less accurate.

The selection of 18 inches as the width of an "average" was arrived at by examining target sizes. Conversations with two target manufacturers revealed that the size of the silhouette targets used by military and police is based upon figures at least 40-50 years old. The 18 inches distance is an "average" man across the front or back between the armpits. It excludes the arms because shots, even lethal shots, on appendages are not very effective. The “B-21” target is used by the LASD and is only 16.5 inches across. The “B-27” target, used in the mid-west and east coast, measures about 20.5 inches.

Accuracy at the longer range of 75 feet was examined using several variables including launcher type, configuration, material, and weight. As can be seen from Figures 19–22, there does not appear to be a strong correlation between any particular variable and accuracy.

In Figure 19, the accuracy data is broken out by launcher type. As can be seen, no single launcher was more accurate than any other was. The 12-gauge shotgun launcher data is highlighted, and the accuracy of those projectiles runs the gamut of the accuracy measurements.

In Figure 20, the accuracy data is examined using configuration of the projectile as a variable. In this case there is some correlation between some configurations and higher accuracy at the longer ranges. For instance, the data for the 12-gauge shotgun fin-stabilized projectiles is highlighted and shows a tight group of higher accuracy relative to other projectile configurations. The 12-gauge shotgun drag-stabilized projectiles have also been highlighted and show a higher variability in accuracy of that projectile configuration.

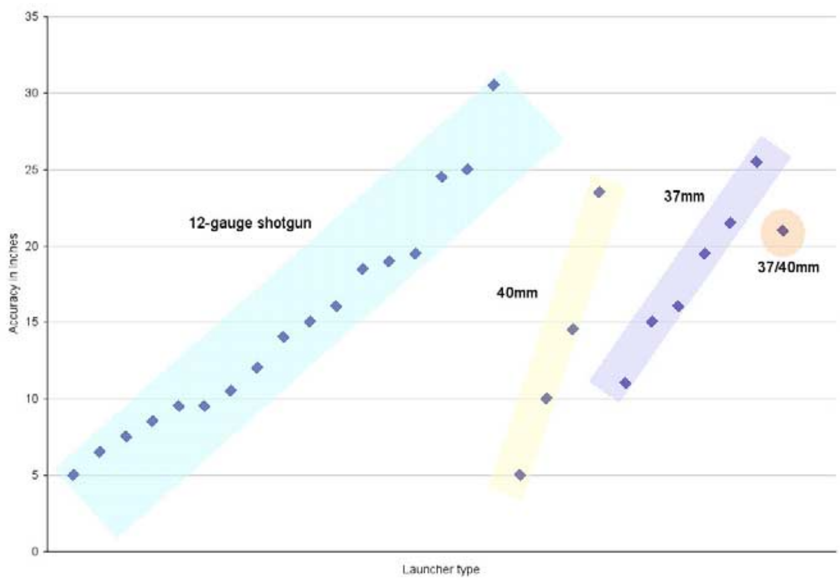

Figure 19. Accuracy of various launchers at a range of 75 feet. The highlighted boxes segregate the dispersion data by launcher type.

A representation of the accuracy data using projectile material as a variable is found in Figure 21. Projectiles that use lead are highlighted. Based on the available data, there does not appear to be a material that produces higher accuracy at a distance of 75 feet.

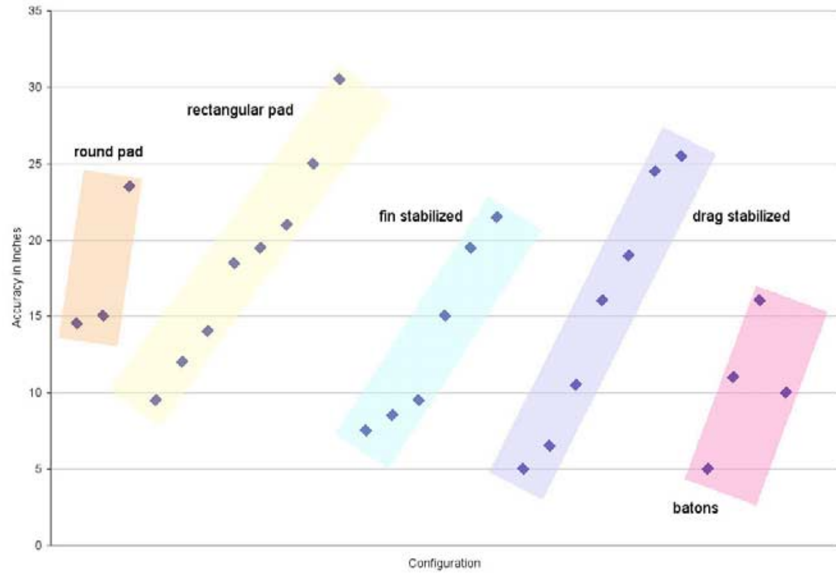

Figure 20. Accuracy of various projectile configurations at a range of 75 feet. The highlighted areas contain the accuracy data from various configurations of projectiles.

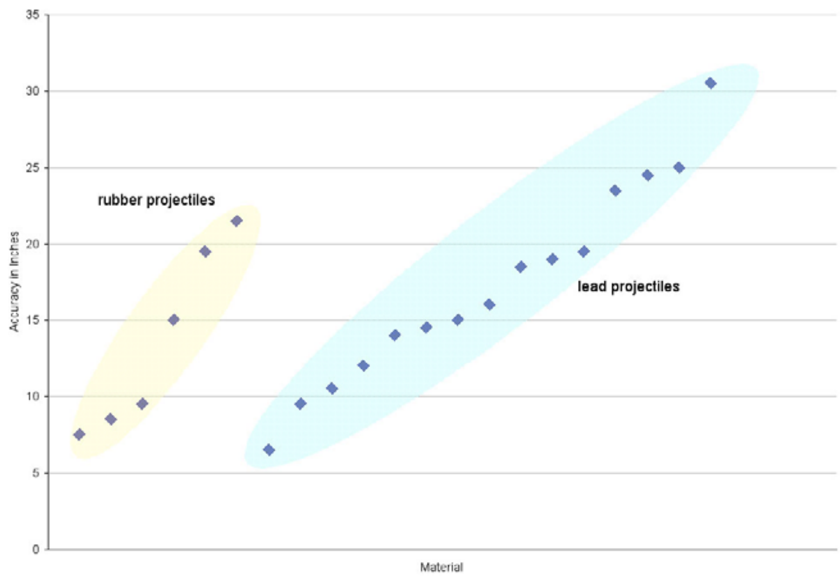

Figure 21. Accuracy of lead and rubber projectile materials at a range of 75 feet.

The last graph in this section, Figure 22, examines accuracy using the variable of weight. Once again there does not appear to be any correlation between the weight of a given projectile and its accuracy at the range of 75 feet. The highlighted box surround those projectiles that weigh approximately 40g, use the material lead, and are fired from the 12-gauge shotgun launcher.

… there does not appear to be any correlation between the weight of a given projectile and its accuracy at the range of 75 feet.

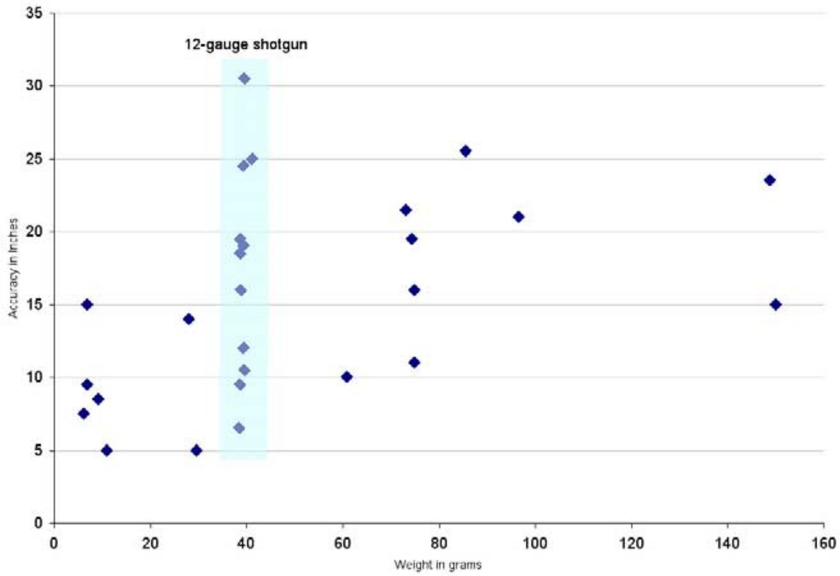

Figure 22. Accuracy of projectiles using the attribute weight as a variable. The highlighted area contains the lead, 12-gauge projectiles with the approximate weight of 40g.

Imparted momentum range 1 (21 feet)

The momentum imparted to the ballistic pendulum was measured for 80 munitions at a range of 21 feet. Momentum is the mass times the velocity of the projectile and was measured in Newton-seconds (an explanation of momentum can be found in the *Measured Attributes* section). These measurements must be used with caution. There has been no attempt to correlate those measurements with impacts on the human body nor has there been an attempt to correlate the measurements to injury probabilities. However, the measurements do provide a relative ranking of the impacts of the various munitions.

Figure 23 displays the impact data sorted by the type of launcher. As can be seen there is a wide range of impacts for any given launcher. The impact velocity (and imparted momentum) has been at the manufacturer's or developer's discretion, which has been generally defined (by the manufacturer) as the near safety limits where a given munition would be effective without resulting in serious injury or death. However, these claims are not based on scientific study or verifiable data. As the figures in this section demonstrate, there is a large range of imparted momentums.

Figure 24 displays the impact data by configuration type. Four configuration types have been highlighted: small pellets, rectangular pads, fin-stabilized, and encapsulated projectile configurations. It can be seen that for all but the encapsulated projectiles there is a large variation in measured impacts. Using small pellet projectiles as an example, the momentum range from a low value of .406 Newton-seconds to a high value of 8.81 Newton-seconds.

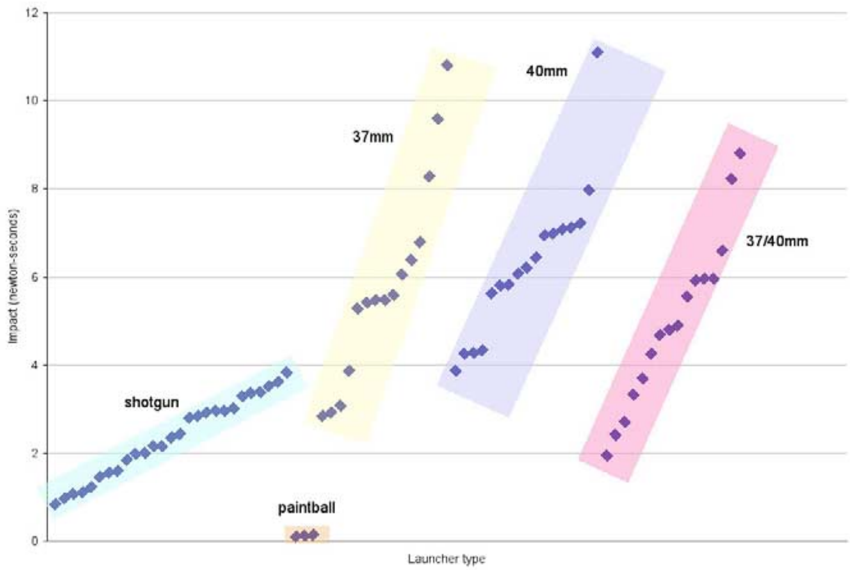

Figure 23. Imparted momentum from various launchers at a range of 21 feet. Momentum is measured in Newton-seconds. The highlighted boxes contain data sorted by launcher type.

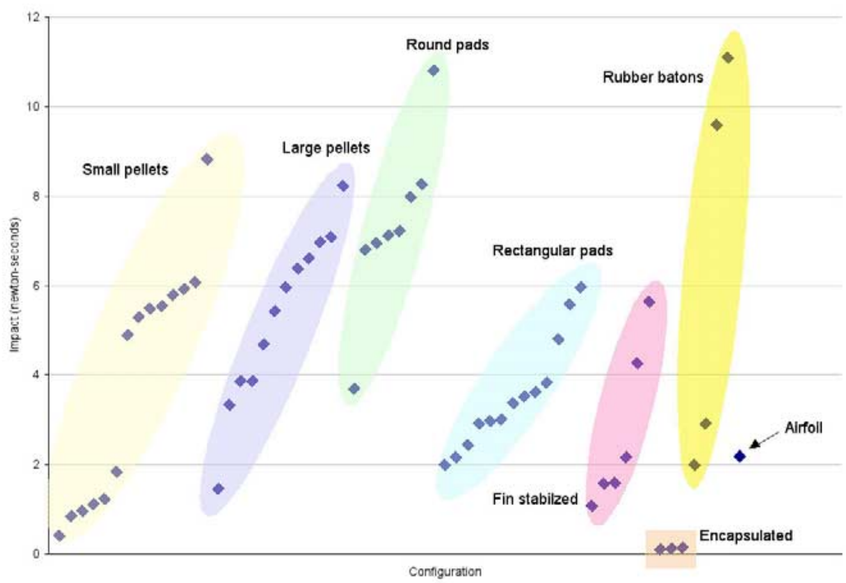

Figure 24. Imparted momentum of various configuration types measured at a range of 21 feet.

Similar trends can be seen in Figure 25. Projectiles of similar materials have a wide range of impact momentums. For example, the impact momentum for rubber pellets range from a low of .406 Newton-seconds to a high of 11.09 Newton-seconds.

As was provided in the *Accuracy* section, imparted momentum is also examined using only the data from the 12-gauge shotgun launcher and with the momentums sorted by projectile configurations. The can be seen in Figure 26. Each of the projectile configurations offers a range on impact momentums at a range of 21 feet.

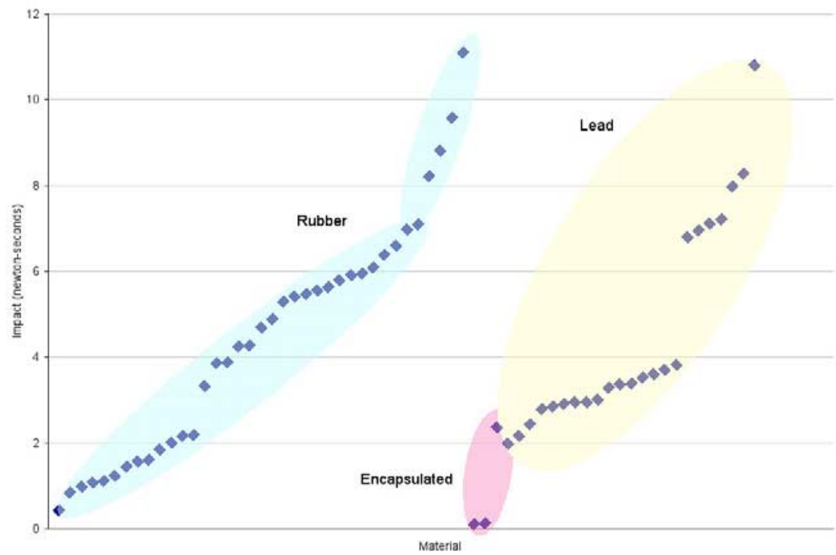

Figure 25. Imparted momentum of various projectiles at a range of 21 feet. The highlighted boxes contain the data for rubber, encapsulated, and lead projectile materials.

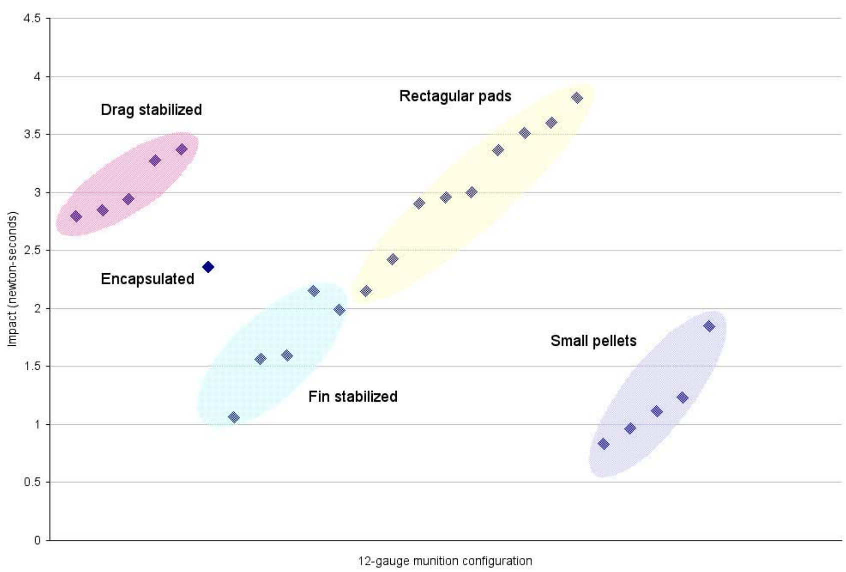

Figure 26. Imparted momentum of various projectile configurations for the 12-gauge shotgun launcher at a range of 21 feet.

Imparted momentum range 2 (75 feet)

The momentum imparted to the ballistic pendulum was measured for 37 munitions at a range of 75 feet. Momentum is the mass times the velocity of the projectile and was measured in Newton-seconds. These measurements must be used with caution. There has been no attempt to correlate those measurements with impacts on the human body nor has there been an attempt to correlate the measurements to injury probabilities. However, the measurements do provide a relative ranking of the impacts of the various munitions.

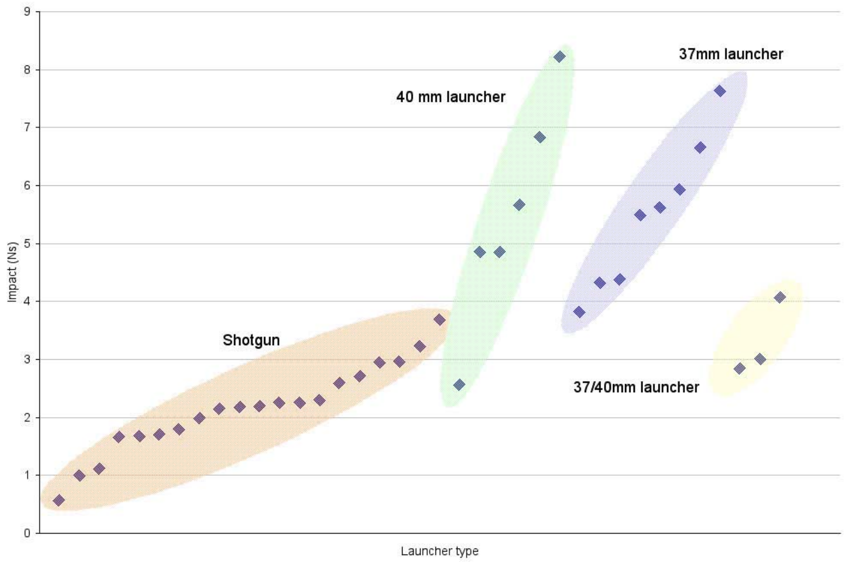

Figure 27. Imparted momentum from various launchers at a range of 75 feet. Momentum is measured in Newton-seconds (Ns).

Figure 27 displays the impact data sorted by the type of launcher and there is a wide range of impacts for any given launcher. For these 37 munitions, the lowest momentum measured at this range was 0.56 Ns and the highest value was 8.21 Ns. As can be seen in this figure, imparted momentum as a function of range, has been at the manufacturer's or developer's discretion, which has been generally defined (by the manufacturer) as the near safety limits where a given munition would be effective without resulting in serious injury or death. However, these claims are not based on scientific study or verifiable data. As was discussed in the previous section, there is a large range of imparted momentums.

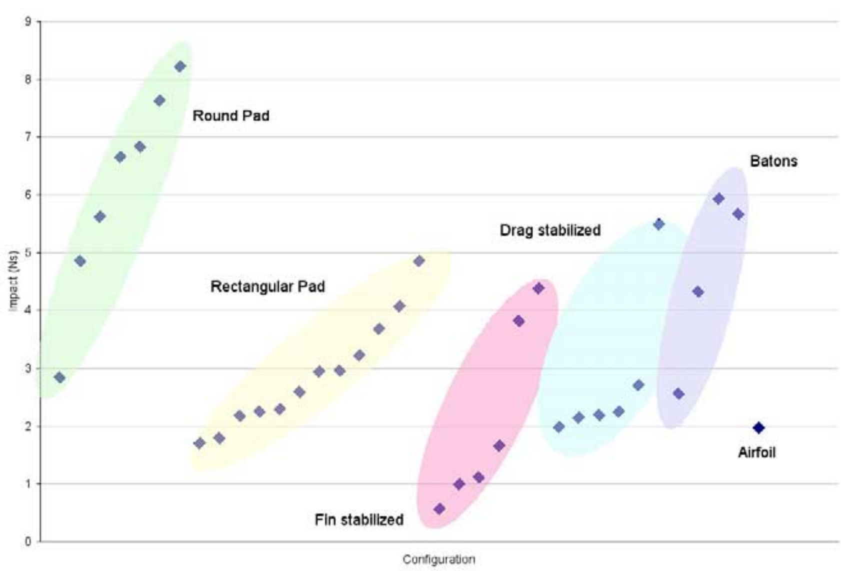

Figure 28. Imparted momentum of various configuration types measured at a range of 75 feet.

Figure 28 displays the impact data by configuration type. The configuration types have been highlighted. It can be seen that for any configuration type there is a large variation in measured momentums. Using small pellet projectiles as an example, the momentum range from a low value of .406 Newton-seconds to a high value of 8.81 Newton-seconds.

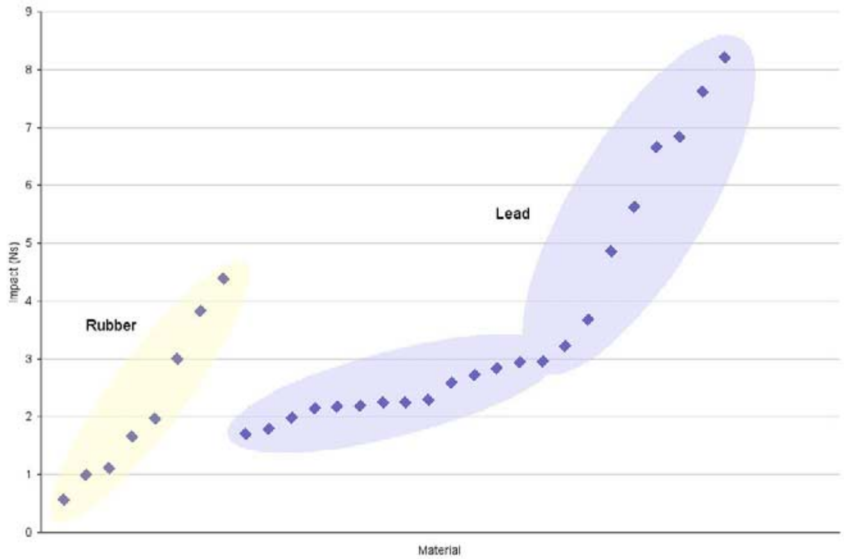

Figure 29. Imparted momentum of rubber and lead projectile materials at a range of 75 feet.

… for any configuration type there is a large variation in measured momentums.

Similar trends can be seen in Figure 29. Projectiles of similar materials have a wide range of impact momentums.

As was provided in the *Accuracy* section, the impact momentum is examined using only the data from the 12-gauge shotgun launcher and with the momentums sorted by projectile configurations. The can be seen in Figure 30. Each of the projectile configurations offers a range on impact momentums at a range of 75 feet.

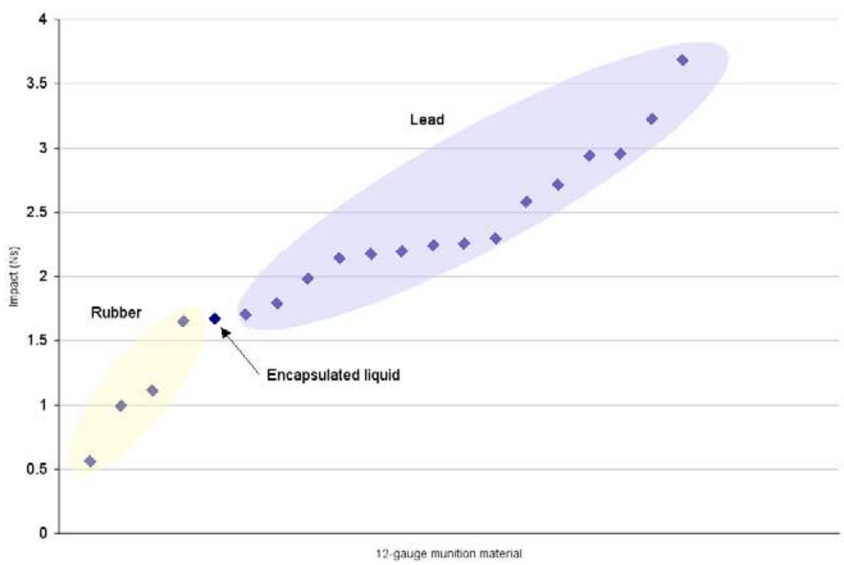

Figure 30. Imparted momentum of various projectile materials for the 12-gauge shotgun launcher at a range of 75 feet.

Configuration

The configuration of a munition is defined as the physical make-up and shape of the projectile(s). Of those munitions tested, there were 14 different configurations. The configuration types and numbers of munitions are shown in Figure 31.

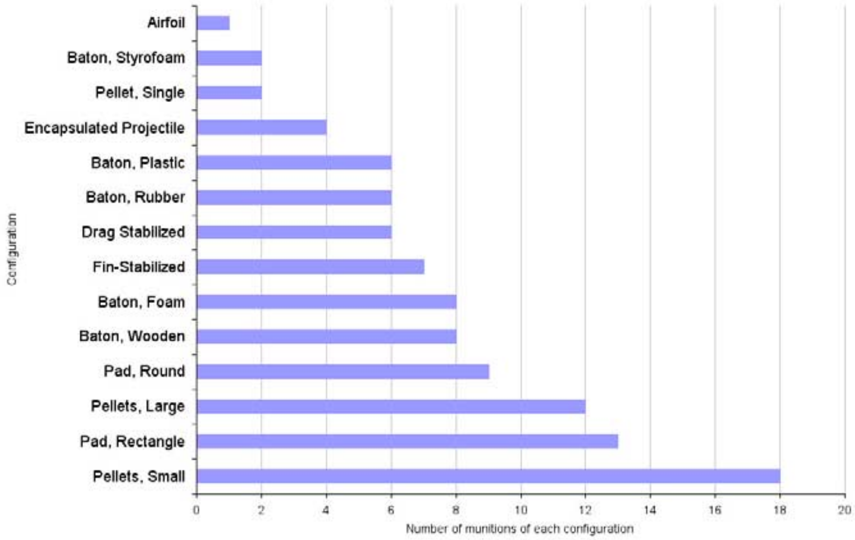

Figure 31. Configuration of extended-range impact munitions by types and numbers. Pellets with a diameter of 0.5 inch or greater were defined as large pellets. Pellets with a diameter of less than 0.5 inch were defined as small pellets.

As can be seen, less-than-lethal extended-range impact munitions come in a variety of configurations. Each configuration attempts to provide some specific effect. The configuration for a specific munition should be used by users for determining the suitability of a particular munition for a given purpose. Some of these configurations are meant to be highly discriminative, which is the ability to strike a single individual at given range. An example of this configuration is the rubber fin-stabilized projectile. Other configurations are meant to be area munitions, which are designed to impact more than one person in close proximity at a given range.

The configurations that are available for the 12-gauge shotgun and 37mm launchers are displayed in Figure 32 and Figure 33. As would be expected, the number of configurations designed for these launchers drop from 14 to 8. However, it should also be noted that both discriminatory and area configurations are available.

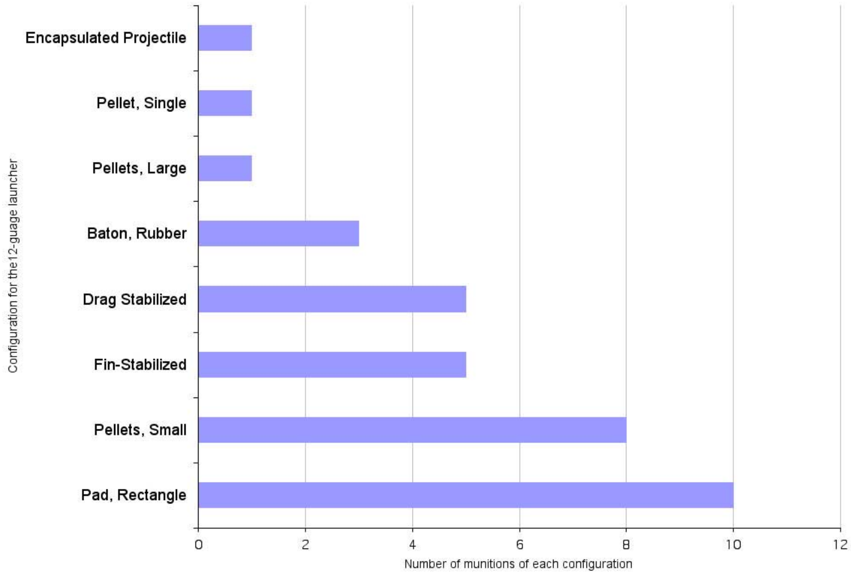

Figure 32. Configuration types and number of munitions for the 12-gauge shotgun launcher.

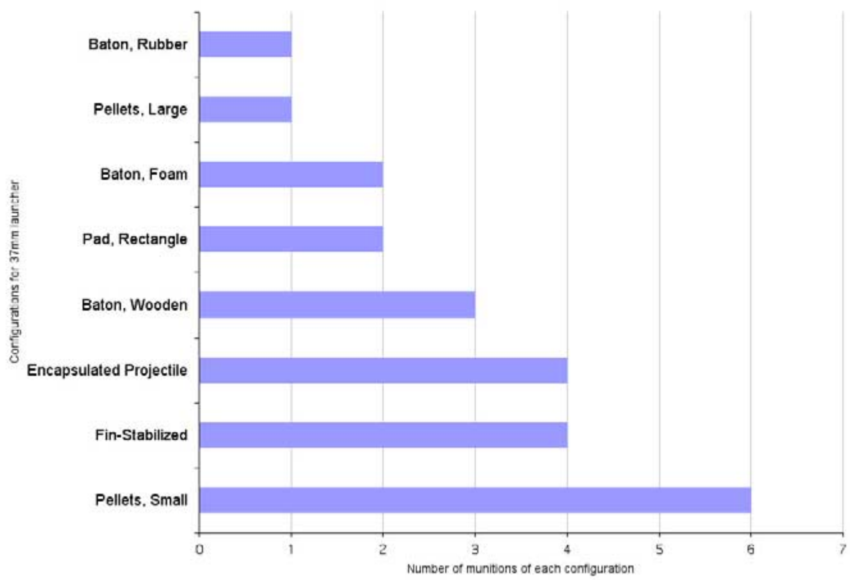

Figure 33. Configuration types and numbers of munitions for the 37mm launcher.

Material

As was described in the *Attribute* section, this attribute describes the primary material that is used to construct the projectile. Projectiles for less-than-lethal extended-range impact munitions come in a variety of materials, such as rubber, lead, steel, silica, and plastic. The accuracy and imparted momentum for the munitions was examined using material as a variable. Those graphs can be found in those sections.

Field identification

Field Identification is the method by which one munition is distinguished from another, especially in low-light conditions. Many less-than-lethal extended-range impact munitions look identical to lethal munitions and use identical launchers. As can be seen in Figure 34, there are seven methods used to identify the munition with the use of text being the overwhelmingly predominant method.

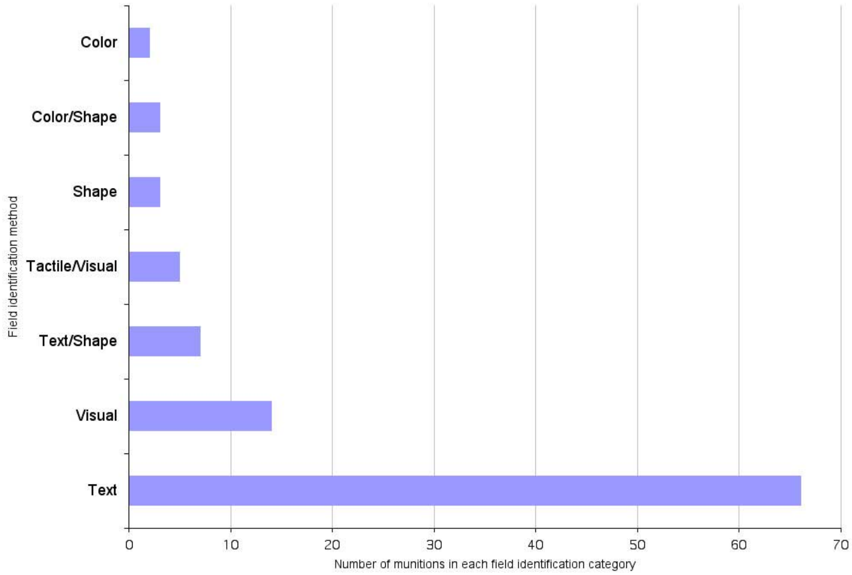

Figure 34. Methods for identifying less-than-lethal munitions and the numbers of munitions in each field identification category.

Figure 35 is a photograph of two 40mm munitions. Only the model numbers and information labels on the sides of the canisters distinguish the different configurations (.32-caliber stingballs and foam batons) from each other. In field applications, this might become troublesome, especially in low light or when labels are obscured or obliterated from handling.

Figure 35.

Photograph of the No. 40mm multiple .32-caliber rubber ball round and the No. 40 F 40mm multiple foam baton round. These rounds rely on text information for identification.

Some manufacturers and developers have attempted to assist in identifying particular munitions by using color, shape, tactile identification (bumps, raised letters, etc.) and other methods. Figure 8 (a photograph of a 37/40mm projectile, a 40mm sponge grenade, and a 12-gauge round with a clear casing) provides examples of types of munitions and the various method of field identification.

Launcher

The launchers used in this test were described in the *Attribute* section. Data for both accuracy and imparted momentum were graphed using launcher type as a variable and those graphs can be seen in those sections. A photograph of the launchers used to conduct this test is found in Figure 36.

Figure 36.

Less-than-lethal munitions come in a variety of styles, configurations and calibers, and require a variety of launchers. This is a photograph of the launchers used to conduct the ABE. Note the green tags on the stocks that record the precise measurement of the inside diameter of the muzzle.

Cartridge size

While the cartridge size for the 12-gauge shotguns are standard, less-than-lethal munitions for the 37mm and 40mm come in a wide variety of sizes, shapes, and configurations. Figures 37–39 breakout these munitions for specific launcher by size. In general, the smaller sized cartridges use lead pads as the projectile and the larger cartridges contain batons.

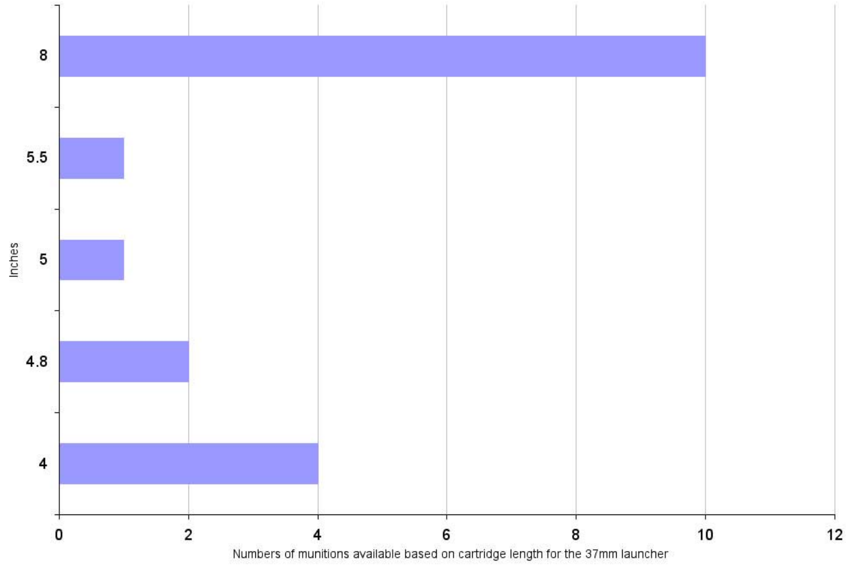

Figure 37. Number of munitions available for the 37mm launcher based on cartridge length.

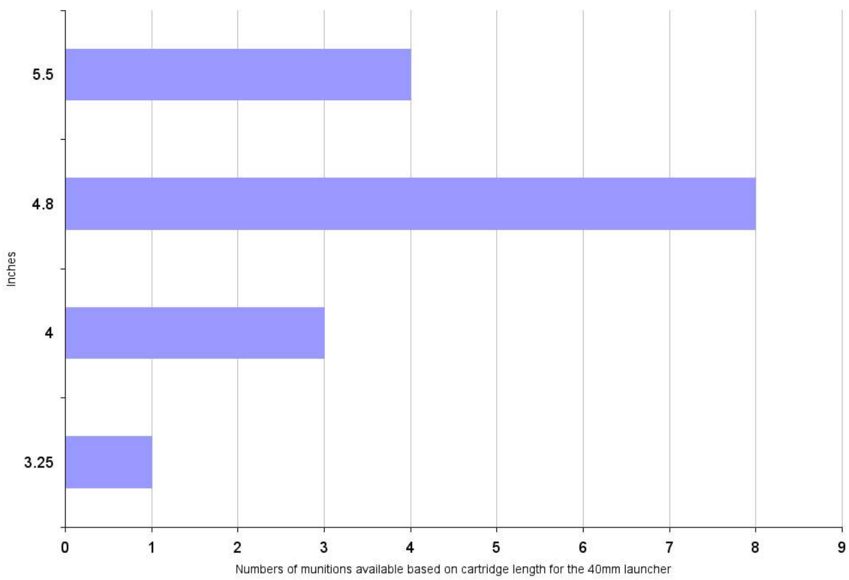

Figure 38. Number of munitions available for the 40mm launcher based on cartridge length.

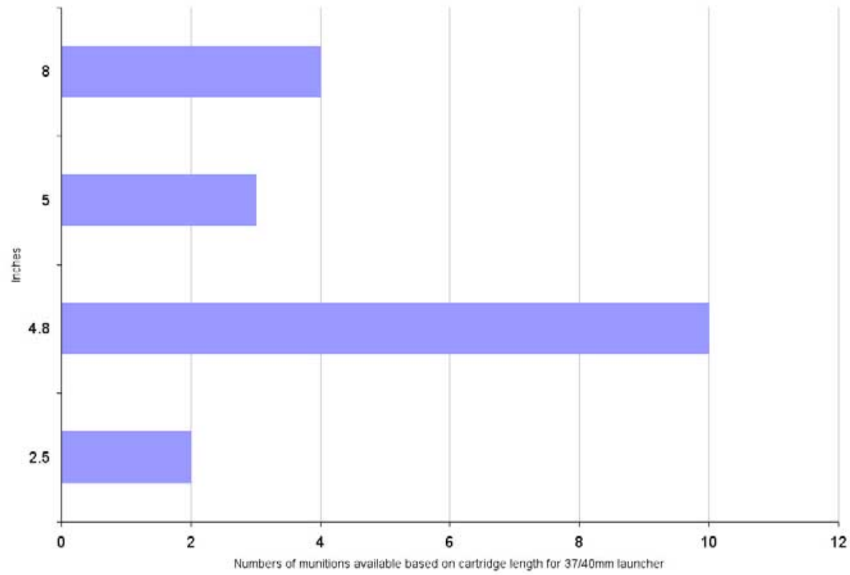

Figure 39. Number of munitions available for the 37mm and 40mm launcher based on cartridge length.

Measured weight

The measured weights of the projectiles can be found in the attribute tables at the end of this report in the appendices. Figure 40 shows the distribution of the weights. The weights range from less than 2 grams to almost 200 grams.

The measured weights of the projectiles… range from less than 2 grams to almost 200 grams.

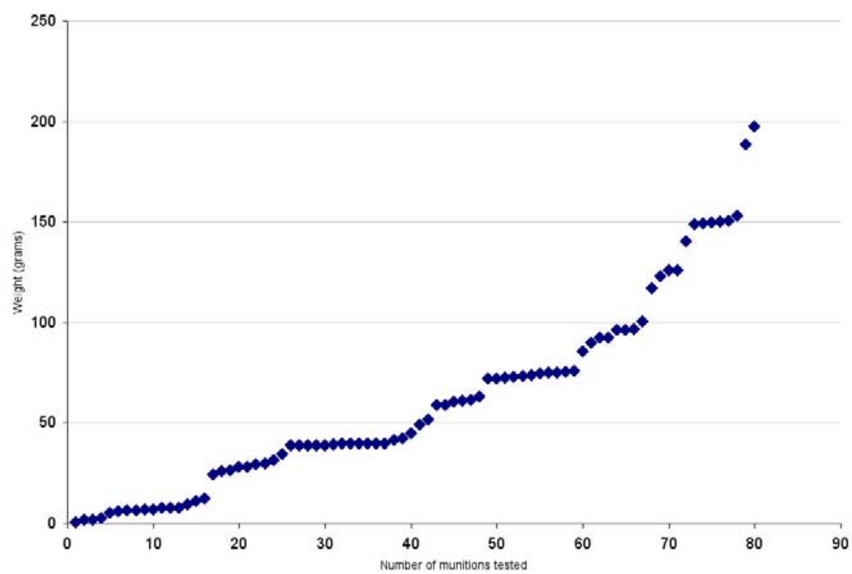

Figure 40. Measured weights of the projectiles of less-than-lethal, extended-range impact munitions.

Number of projectiles

The majority of tested munitions contained a single projectile, which means that these munitions were intended for use against a single target. Forty-four of the munitions (55%) tested were discriminate munitions. As can be seen in Figure 41, the remaining 36 contained multiple projectiles. The number of multiple projectiles in a single cartridge ranged from 2 to 300.

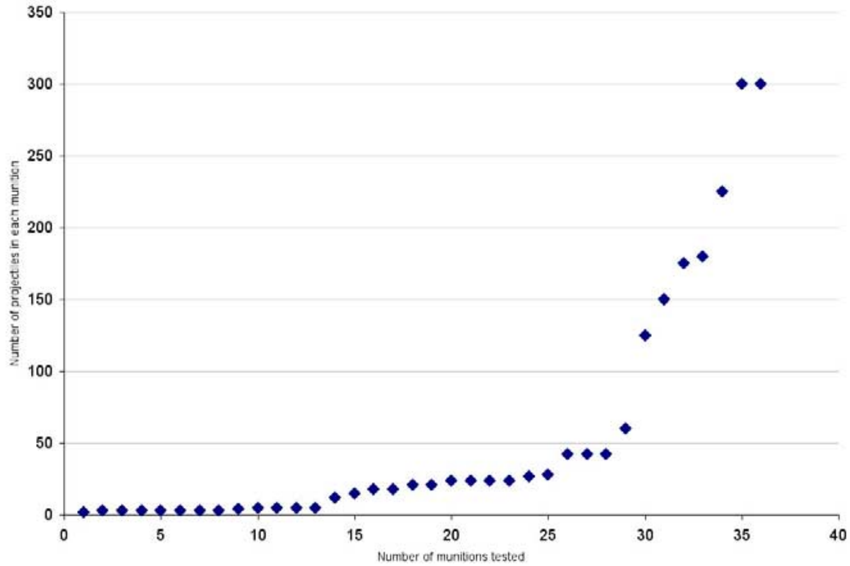

Figure 41. Number of less-than-lethal, extended-range impact munitions with multiple (2–300) projectiles in a single cartridge.

…the prices ranged from a low of $1.60 to a high of $25.30 per round.

Retail price

Ninety-three munitions were commercially available at the time this test was conducted. The manufacturers provided retail prices, and the prices ranged from a low of $1.60 to a high of $25.30 per round. Volume discounts were not considered. Figure 42 is a graphic representation of the price range.

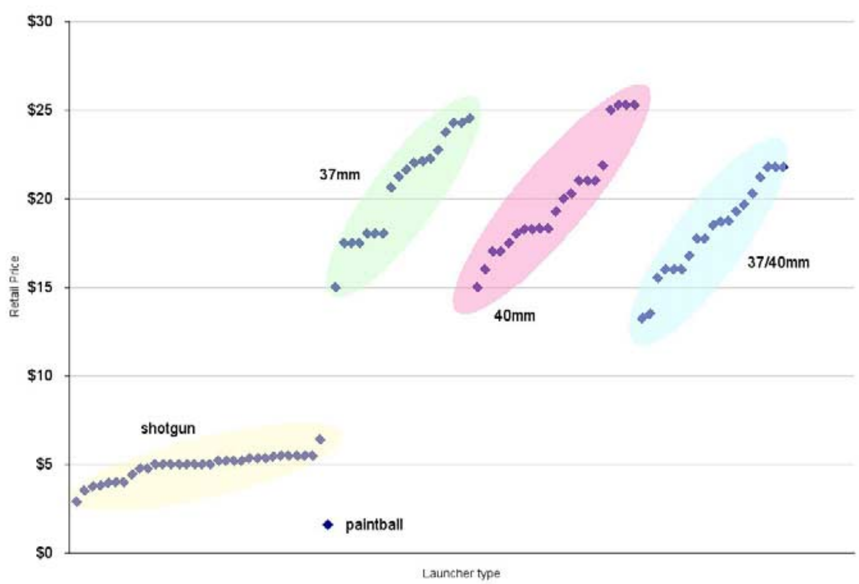

Figure 42. Graphic representation of the price variability of non-lethal extended-range impact munitions by launcher types. The prices vary from $1.60 to $25.30.

An important consideration in the purchase of any type of ammunition is cost, and the smart user is interested in receiving the most “bang for his buck”. As was discussed earlier, the price of a shotgun-launched non-lethal munition can exceed the price of its lethal counterpart by as much as ten times. Furthermore, for every munition purchased for field use, four or five are purchased for training and qualification purposes. Consequently, the price of a particular munition can become one critical factor in the decision of which munition should be purchased and can be the deciding factor between two similar munitions. To make those types of decisions it is important to arrive at the desired conclusion through proper comparison of the data. In the case of retail price, it may be important to compare prices after you have selected the ammunition type and launcher.

For example, Table 1 breaks down the ammunition by types and provides the low and high price for each type.

Table 1. Comparison of low and high retail price by ammunition type.

TYPE	NUMBER EVALUATED	LOW PRICE ($)	HIGH PRICE ($)
Shotgun	32	2.90	6.40
40mm	17	15.00	24.50
37mm	21	15.00	25.30
37/40mm	19	13.25	21.75

Table 2 is a further breakdown of the price comparison. In this case, 12-gauge rubber fin-stabilized projectiles are listed by price. As can be seen, there is a fairly large variation in price. The Defense Technology round is almost twice the cost of the Technical Solutions round. It is also interesting to note that five of the manufactures produce this configuration of less-than-lethal round. See Figure 4 for a photograph of various fin-stabilized projectiles.

Table 2. Price comparison of 12-gauge rubber fin-stabilized projectiles.

MANUFACTURER	MODEL	RETAIL PRICE ($)
Defense Technologies	23FS Rubber Fin-stabilized	$5.50
Royal Arms International	FIN-12 Fin-stabilized Rubber Baton	$5.00
MK Ballistics Systems	RB-1-FS Rubber Fin-stabilized Baton	$4.99
ALS Technologies	Rocket	$3.75
Technical Solutions	Rubber Fin-stabilized	$2.90

The complete list of munitions and prices are found in *Appendix C*.

Availability

Of the 80 different types of munitions that were tested, six were not commercially available at the time of the evaluation (see Table 3). However, based on information from the manufacturer, these munitions will be commercially available within the next 24 months.

Table 3. List of less-than-lethal, extended-range impact munitions that were tested but not commercially available at the time that the attribute-based evaluation was conducted.

MANUFACTURER	MODEL	CONFIGURATION	LAUNCHER
Edgewood Arsenal	Ring Airfoil Projectile	Airfoil	Special
Sage, Inc.	KO-3P	Baton, Styrofoam	37mm
Sage, Inc.	KO-3LEP	Baton, Styrofoam	37mm
Jaycor	Malodorant	Encapsulated Projectile	Paintball
ALS Technologies	Power Punch, Pen-Prevent	Drag-stabilized	Shotgun

Method of engagement

The primary method of engagement used during this test was the direct fire method. The test set up did not lend itself to measuring accuracy or impacts from skip fired rounds. At the end of the test period, we did conduct a few skip fired tests and those observations can be found in the *Observations and Recommendations* section.

The primary method of engagement used during this test was the direct fire method.

Special features and comments

The special features and comments attributes identified any special or unusual features of a particular munition. As less-than-lethal munitions continue to be improved, some manufacturers and developers have provided additional features to enhance the use of a particular munition. For instance, some munitions contain dye-markers or colored-dust for "tagging" suspects for later arrest or are "liquid-filled" so that chemical agents can be employed, and so forth. The special features and comments can be found in the appendices.

Observations and Recommendations

Notice of non-endorsement

The Los Angeles County Sheriff's Department and the Institute for Emerging Defense Technologies, through Penn State's Applied Research Lab, do not endorse any specific product that was tested during the course of this study or is mentioned in this report. The Attribute-Based Evaluation (ABE) is not intended to indicate measures of effectiveness, make assumptions about minimum and maximum ranges, identify potential injury, or make any recommendations as to which brand is more suited for a given purpose. Nevertheless, this study is intended to provide critical data in a usable and understandable format to allow law enforcement and military personnel to reasonably compare like information and make an informed decision on the suitability of a particular munition for a given purpose.

Suggestions and examples of how to use the data

Example 1

An example of how this data might be used is provided in this section. This example should not be construed as an endorsement of any particular munition. Nor should the reader feel constrained to use this example to make a decision on which type of munition to use. Rather it is meant to illustrate a method to use the data to arrive at informed decisions regarding less-than-lethal, extended-range impact munitions.

An example… is provided… to illustrate a method to use the data to arrive at informed decisions regarding less-than-lethal, extended-range impact munitions.

In this example, the first assumption is that a law enforcement agency would like to use less-than-lethal, extended-range impact munitions that were designed to use the 12-gauge shotgun as the launcher. The first step is to sort the data by launcher and eliminate those munitions that do not use the 12-gauge shotgun launcher. That results of this data sort is presented in Figure 43. As can be seen, the number of eligible munitions based on this assumption is 27.

The second assumption is that the law enforcement agency is looking for a munition that can be accurately fired at a range of 21 feet. The desired accuracy is a 10-inch or less dispersion. This subset is presented in Figure 44. Four of the 27 munitions are eliminated by this desired accuracy.

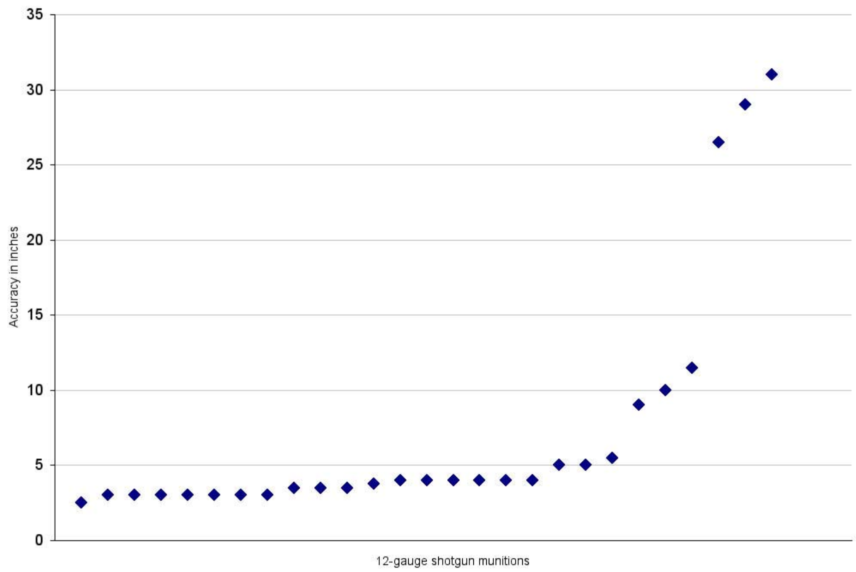

Figure 43. Example 1: Segregation of less-than-lethal, extended-range impact munitions by 12-gauge shotgun munitions and accuracy.

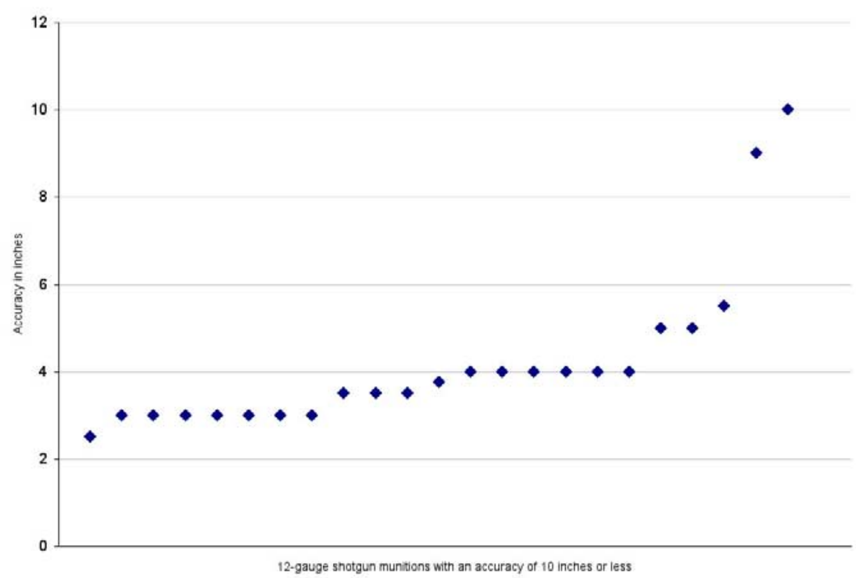

Figure 44. Example 1: 12-gauge less-than-lethal, extended-range impact munitions segregated by dispersions of 10 inches or less at a range of 21 feet.

The third assumption is that this particular agency is concerned with both the cost of not only providing sufficient rounds to its law enforcement officers for use in appropriate situations, but also the cost of the rounds required for training. They would like to spend $4.00 or less per round. This subset is presented in Figure 45. Of those munitions, two are not commercially available, and this agency want to purchase a munition now. Therefore, those two munitions are eliminated from the selection process. The number of eligible munitions has now been reduced to five.

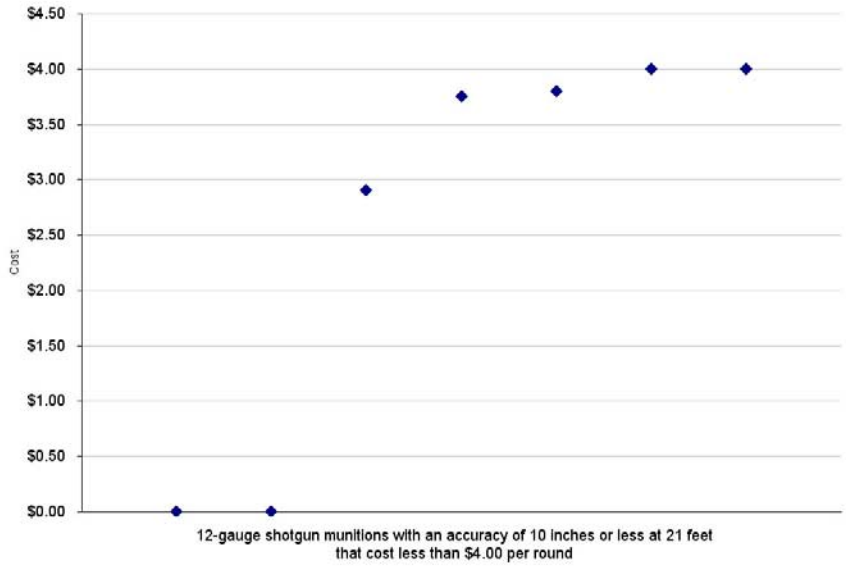

Figure 45. Example 1: Segregation of 12-gauge munitions with an accuracy of 10 inches or less at a range of 21 feet and a cost of $4.00 or less.

Following this set of assumptions, it leads the user to this small set of munitions found in Table 4 from which to choose. It can be seen that one of the munitions is an encapsulated projectile. If the user is interested in only those munitions that rely on extended-range impact of effect than that munition may also be eliminated.

Table 4. Example 1: Final subset of eligible less-than-lethal, extended-range impact munitions.

MANUFACTURER	COST ($)	CONFIGURATION
Technical Solutions	2.90	Fin-Stabilized
ALS Technologies	3.75	Fin-Stabilized
Technical Solutions	3.80	Pad, Rectangle
Technical Solutions	4.00	Encapsulated Projectile
Royal Arms International	4.00	Pellets, Small

Example 2

A second example is provided. And once again it is accompanied with this caution. This is not an endorsement of particular products. Rather it is meant to be an example of how the data might be used.

In this case, the first assumption is that the law enforcement agency would like to use less-than-lethal, extended-range impact munitions that are accurate at a range of 75 feet. Their accuracy criterion is that the dispersion of this munition must be 15 inches or less. The results of this segregation can be seen in Figure 46.

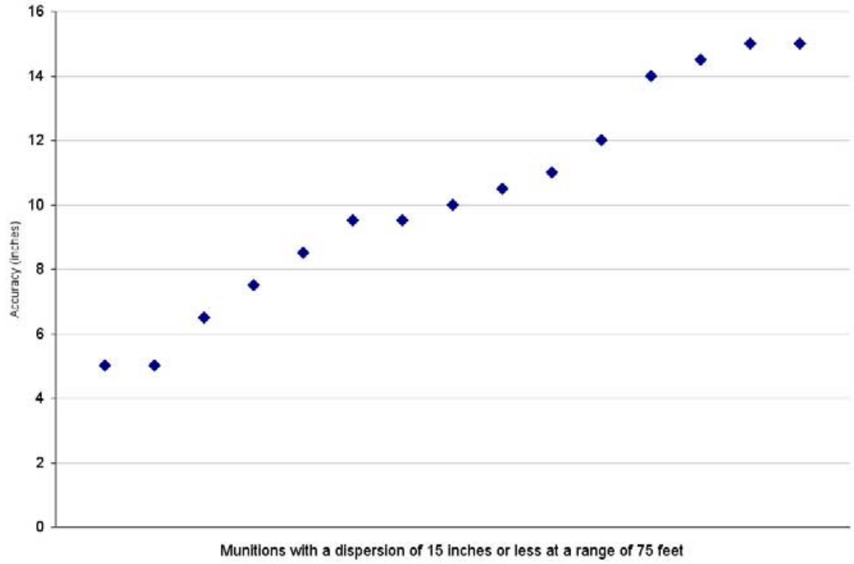

Figure 46. Example 2: Less-than-lethal extended-range impact munitions with a dispersion of 15 inches or less at a range of 75 feet.

As can be seen, the first assumption culls the eligible munitions down to 15. The second assumption is that the law enforcement agency uses the 12-gauge shotgun and desires to use that weapon as its primary launcher for less-than-lethal projectiles. The result of this segregation is seen in Figure 47 and further reduces the eligible munitions to ten.

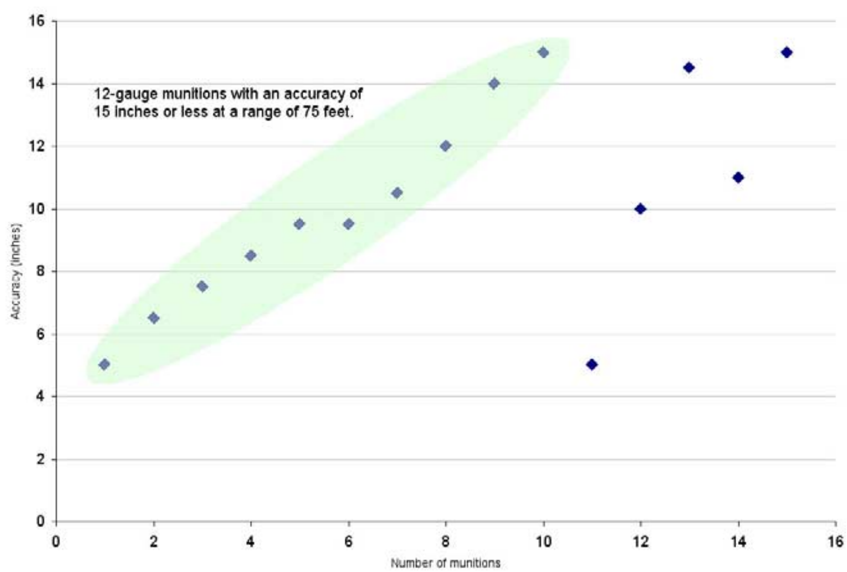

Figure 47. Example 2: Segregation of munitions by launcher type. The green area highlights the 12-gauge, less-than-lethal munitions that have an accuracy of 15 inches or less at a range of 75 feet.

The third assumption is that this particular agency is concerned with the availability and, of the remaining munitions, one is not commercially available. This agency is also concerned with cost. The result of that sort is seen in Figure 48.

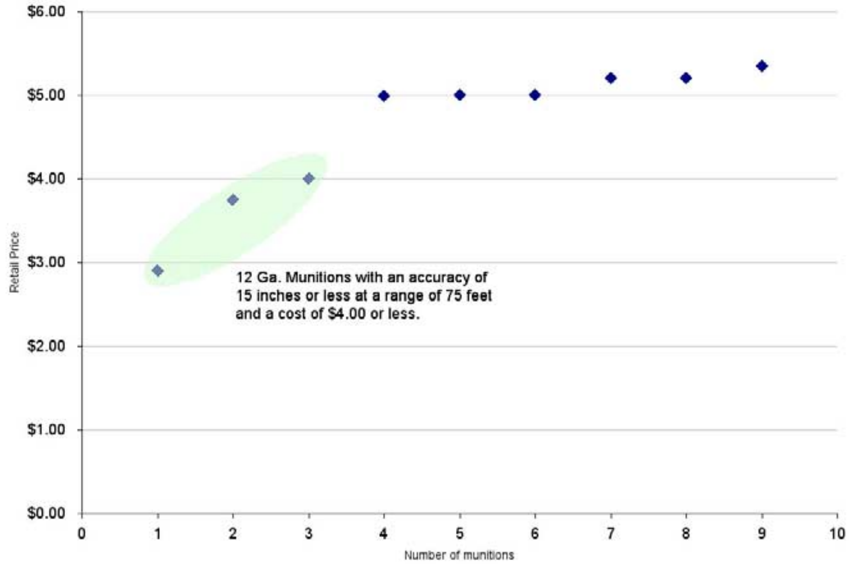

Figure 48. Example 2: Segregation of 12-gauge munitions by cost. The green area highlights those 12-gauge munitions that have an accuracy of 15 inches or less at a range of 75 feet, are commercially available, and cost $4.00 or less.

Now that the number of munitions has been culled down to three, the agency is now interested in the munition that is the most accurate and provides the highest accuracy at 75 feet, which ends the selection process with the identification of a single munition as shown in Figure 49.

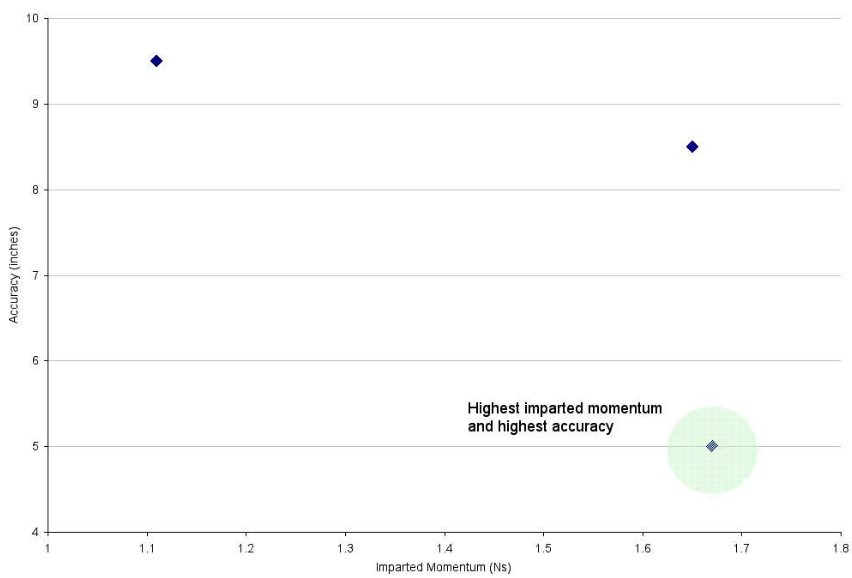

Figure 49. Example 2: The final sort identifies the munition that has the highest momentum and accuracy at a range of 75 feet.

It is a rare opportunity to fire all of these types of munitions over an intense two-day period and certain observations were made during that time.

Our observations without endorsement

Although it would be inappropriate to endorse some munitions or manufacturers, it would be equally inappropriate if we did not pass on some of our observations about these munitions. It is a rare opportunity to fire all of these types of munitions over an intense two-day period and certain observations were made during that time. Bear in mind that only five rounds of each type of munitions were fired. So these observations are about munitions taken as a whole and not about any particular munition type.

Accuracy

We were struck by the general inaccuracy of these munitions. As can be seen from the data, some configurations were more accurate than others. However, there were very few direct fire munitions that could be used accurately at a range of 75 feet.

Thirty-seven extended-range impact munitions were fired at a range of 75 feet. Of those 37 munitions:

- 17 had an accuracy dispersion of 18 inches or less (46%)
- 11 had a dispersion greater than 18 in. but equal to or less than 36 in. (30%)
- 9 could not reliably hit the impact plate (24% overall). It is interesting to note that of these nine munitions, all of them had small dispersions at the 21-foot range and that the predominant configuration was the pad. Although the data set is very small, a conclusion might be drawn that the pad configuration may have a tendency to "sail" at longer ranges and become less accurate.

Reliability (misfires, fouled bores, muzzle velocity variability)

There may be very few things more embarrassing and, more importantly, dangerous to a law enforcement officer than a misfire, and we observed several misfires. In each of the misfires, the firing pin had struck the primer.

There were also several occasions of foul bores where the projectile remained lodged in the barrel after firing. This was obviously another extremely dangerous situation. In a calm test environment, the occurrences of fouled bores were readily observed. In a tactical environment, detection of a projectile that remains lodged in the barrel may be more difficult to detect and that presents a dangerous situation. The barrel must be cleared before another round is fired. This concern might be addressed procedurally by the using law enforcement agency.

We also observed some large variations in imparted momentum for a single type of munition. For example, within the five rounds fired of a single type of munition, the highest imparted momentum could be almost three times that of the lowest imparted momentum. The human effect impact of this type of variation could range from ineffective to tragic.

Given the small number of observations, it was not possible to determine the cause for these variations and malfunctions. Whatever the cause, it would be wise for the government or using organization to support this type of testing for larger lots of the munitions to determine if there are reliability problems.

Skip firing

At the end of the test period, we fired several multi-pellet munitions using the skip fire method. As mentioned previously, the test set up was not ideal for the skip fire method. Nevertheless, we did observe that skip fire did tend to focus the pellets on the target with little or no loss in imparted momentum as compared to direct fire shots. The floor at the test facility was hard, smooth concrete, which is the ideal surface for

. . . we observed several misfires.

. . . several occasions . . . where the projectile remained lodged in the barrel after firing.

We . . . observed some large variations in imparted momentum for a single type of munition.

. . . skip fire did tend to focus the pellets on the target . . .

skip firing. Furthermore, the pellets tended to remain in a low trajectory making them less likely to strike the higher parts of the body such as the face and neck.

The baseball comparison

It has been often said that getting hit with a less-than-lethal, extended-range impact projectile is similar to getting hit with a baseball. As part of this test, it was decided to check the accuracy of this statement. To do that, an official hardball was thrown at the impact plate from a distance of 30 feet. The ball had a cork center, was wool wound, and had a stitched leather cover. It weighed 140.96 grams. The average momentum was 4.273 Ns. Figures 50–51 compare the momentum and weight of the baseball to the less-than-lethal, extended-range impact munitions.

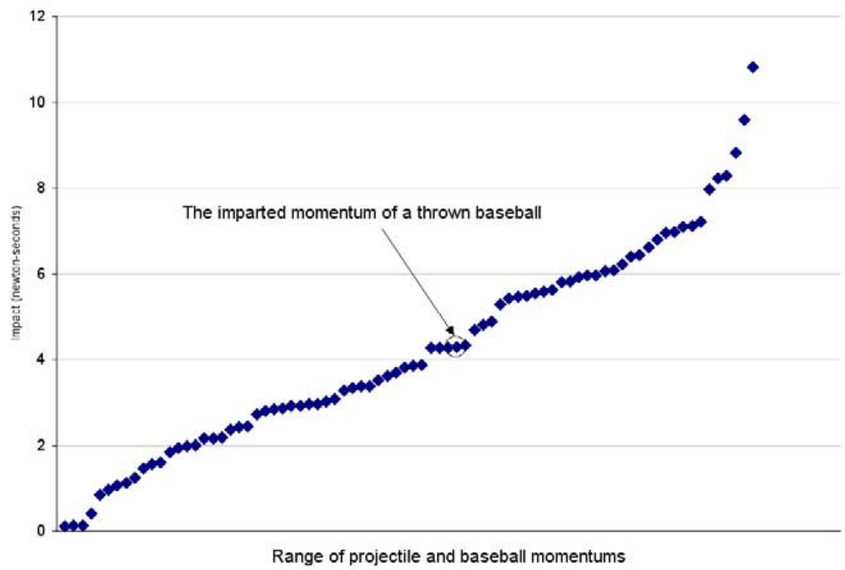

Figure 50. A comparison of the baseball momentum to the momentums of the less-than-lethal munitions.

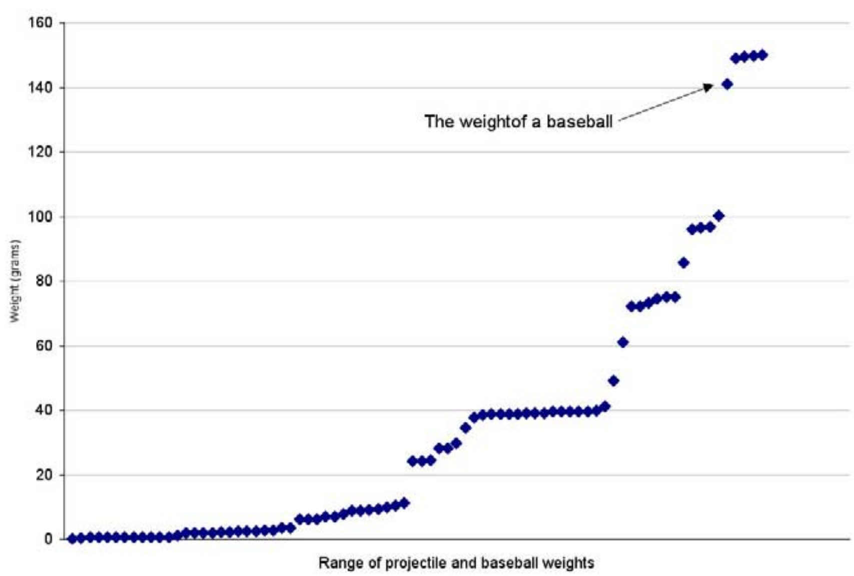

Figure 51. A comparison of the weight of a baseball to the weight of less-than-lethal, extended-range impact projectiles.

As can be seen from the two figures, the momentum of the baseball was in the middle range of the imparted momentums from the less-than-lethal munitions.

Recommendations for future research

The next steps

This test was a "low-tech" rapid attempt to provide much needed information about less-than-lethal, extended-range impact munitions. In part, it was rapid and low-tech because it relied on the generous donations of time and equipment by Penn State and the Los Angeles Sheriff's Department as well as the donations of munitions by the manufacturers (which in itself is an indication that the manufacturers are anxious to have their munitions fairly tested head to head). It was meant to show the value of this data and to open the door to further, more detailed testing. It was also meant to encourage those appropriate government agencies to fund this important area of research

… the momentum of the baseball was in the middle range of the imparted momentums from the less-than-lethal munitions.

The following is a list of the research that should be conducted as a follow-on to this report:

A more comprehensive repeat test with more rounds (improved statistics)

Only five rounds of each munition were tested. This is a very small sample set. From such a small set, it is very difficult to make concrete observations. However, this small data set does provide pointers or flags to those types of munitions that should be further tested. It may not be necessary to test all of the extended-range impact munitions. For example, the data in this report breaks out the attributes of accuracy and imparted momentum. Given that as a starting point, the munitions for a more comprehensive test could be derived from those that are the most accurate or that have momentum above and below selected points.

Skip firing

When operationally feasible, skip firing of pelleted extended-range impact munitions may be the safest method of deployment. Our few observations led us to suspect that the pellets, when skip fired, are focused on the intended target and that the imparted momentum is not significantly diminished. However, more testing is certainly required.

Follow-on research should conduct actual measurements of the impact velocity.

Energy transfer and finite element modeling

The amount of energy that was transferred to the ballistic pendulum was accurately measured during this test. However, this is not the amount of energy that can be transferred by these munitions. All of the impacts were elastic and some of them were highly elastic. In fact, the ricochets from some of the rubber baton rounds could be dangerous to the user. Follow-on research should conduct actual measurements of the impact velocity. Once that velocity is known, the real imparted momentum can be calculated and finite element modeling can be conducted. This modeling will help us understand the momentum that is imparted to the human body and, eventually, understand and predict the potential for injury.

Skin penetration

Skin penetration studies have been conducted using objects of varying diameters fired at varying velocities. Using the imparted momentum measurements from this test, some predictions concerning the probability for skin penetration might be made by leveraging the results of these precious skin penetration studies.

Accuracy improvement

These less-than-lethal, extended-range impact munitions need to be more accurate. As was mentioned in the beginning of this report, the dispersions that were observed during this test would be unacceptable for lethal munitions. Research should be conducted to improve the accuracy in these munitions.

These less-than-lethal, extended-range impact munitions need to be more accurate. …the dispersions that were observed during this test would be unacceptable for lethal munitions.

Barriers to cost reduction

Although this does not fit neatly into the category of research, a better understanding of why these types of munitions are expensive would be helpful. From our inspection of the munitions, there was no obvious reason for their relative expensiveness. There were no exotic materials. For some munitions, there did not appear to be any rigorous quality control. The production process appeared to be simple and straightforward. There do not appear to be any unusual packaging, shipping or storage requirements. These munitions use the same canisters, powder, primers, and casing as their lethal munition counterparts. Given all that, it would not be unreasonable to expect the prices of these munitions to more closely mirror those of their lethal counterparts. Certainly a price reduction would encourage more agencies to equip themselves with less-than-lethal munitions.

… a better understanding of why these types of munitions are expensive would be helpful.

Conclusions and Summary

ARL Penn State's Institute for Emerging Defense Technologies and the Los Angeles Sheriff's Department recognized the need to conduct a preliminary evaluation of less-than-lethal, extended-range impact munitions. We teamed up to do that job and using hard work, imagination, and a very small amount of funding completed the Attribute-Based Evaluation of these types of munitions.

This report and database is available to anyone interested via a web site: www.arl.psu.edu/areas/defensetech/defensetech.html.

This report is a snapshot. The attribute data will change as the manufacturers continue to improve these munitions.

This report is a snapshot. The attribute data will change as the manufacturers continue to improve these munitions. However, the data and observations found within report should provide a big payoff to the law enforcement community as well as the military community. For the first time, a user of less-than-lethal munitions can make an informed decision about which type fits his need. Hopefully, this work is the first step in better understanding the capabilities and limitations of less-than-lethal munitions. We hope that this report will be followed by research that continues to expand our knowledge of less-than-lethal weapons and their human effects.

The following appendices contain all of the data segregated by attribute.

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Table 1.
RETAIL PRICE, AVAILABILITY, CONFIGURATION, AND CARTRIDGE SIZE.

ID	Manufacturer	Model	Retail Price ($U.S.)	Availability	Configuration	Cartridge Size
2	Defense Technologies	27A Stinger	$16.00	Available	Pellets, Small	5"
3	Defense Technologies	27B Stinger	$19.25	Available	Pellets, Small	8"
4	Defense Technologies	37A Stinger	$19.25	Available	Pellets, Small	4.8"
5	Defense Technologies	40A Stinger	$22.25	Available	Pellets, Small	4.8"
6	Defense Technologies	28A Stinger	$18.25	Available	Pellets, Large	5.5"
7	Defense Technologies	28B Stinger	$21.85	Available	Pellets, Large	8"
8	Defense Technologies	37B Stinger	$21.75	Available	Pellets, Large	4.8"
9	Defense Technologies	40B Stinger	$24.50	Available	Pellets, Large	4.8"
13	Defense Technologies	37F Foam Rubber Multiple Baton	$20.25	Available	Baton, Foam	4.8"
14	Defense Technologies	40F Foam Rubber Multiple Baton	$22.75	Available	Baton, Foam	4.8"
18	Defense Technologies	37BR-S Bean Bag	$21.75	Available	Pad, Rectangle	4.8"
19	Defense Technologies	37BR-BP Bean Bag	$21.75	Available	Pad, Rectangle	4.8"
20	Defense Technologies	40BR Bean Bag	$24.25	Available	Pad, Rectangle	4.8"
21	Defense Technologies	Exact Impact 1006	-	Available	Baton, Rubber	4"
22	Defense Technologies	23DS Drag Stabilized	-	Available	Drag-Stabilized	12 ga.
23	Defense Technologies	23BR Bean Bag	$5.50	Available	Pad, Rectangle	12 ga.
28	Combined Tactical Systems	2552 Sting-Ball	$5.35	Available	Pellets, Small	12 ga.
29	Combined Tactical Systems	2553 Sting Ball, High-Velocity	$5.35	Available	Pellets, Small	12 ga.
30	Combined Tactical Systems	2581 Super-Sock	$5.35	Available	Drag-Stabilized	12 ga.
31	Combined Tactical Systems	3551 Foam Baton	$18.75	Available	Baton, Foam	4.8"
32	Combined Tactical Systems	3555 Foam Baton	$19.65	Available	Baton, Foam	8"
33	Combined Tactical Systems	3553 31 caliber Sting ball	$16.00	Available	Pellets, Small	4.8"
34	Combined Tactical Systems	3556 31 Caliber Sting Ball	$18.70	Available	Pellets, Small	8"
35	Combined Tactical Systems	3554 60 Caliber Sting Ball	$17.70	Available	Pellets, Large	4.8"
36	Combined Tactical Systems	3557 60 Caliber Sting Ball	$21.20	Available	Pellets, Large	8"
39	Royal Arms International	HN Hornet's Nest Rubber Buck	$4.00	Available	Pellets, Small	12 ga.
40	Royal Arms International	BB-L Low Power	$5.00	Available	Pad, Rectangle	12 ga.
41	Royal Arms International	BB-M Medium Power	$5.00	Available	Pad, Rectangle	12 ga.
42	Royal Arms International	BB 12-H Heavy Power	$5.00	Available	Pad, Rectangle	12 ga.
43	Royal Arms International	FIN-12 Fin-Stabilized Rubber Baton	$5.00	Available	Fin-Stabilized	12 ga.
44	Jaycor	Pepperball - Pepper dust	$1.60	Available	Encapsulated Projectile	.68 Caliber
45	Jaycor	Pepperball - Liquid-filled	-	Emerging	Encapsulated Projectile	.68 Caliber
47	Combined Tactical Systems	4557 Sponge Baton	$24.25	Available	Baton, Foam	4"
48	Combined Tactical Systems	4551 Foam Baton	$22.10	Available	Baton, Foam	4.8"
49	Combined Tactical Systems	4553 .31 caliber Sting Ball	$21.60	Available	Pellets, Small	4.8"
50	Combined Tactical Systems	4554 .60 Caliber Sting Ball	$23.75	Available	Pellets, Large	4.8"
51	ALS Technologies	Hornets Nest	$3.95	Available	Pellets, Small	12 ga.
52	ALS Technologies	Tri-Dent	$3.50	Available	Pellets, Large	12 ga.
53	ALS Technologies	Rocket	$3.75	Available	Fin-Stabilized	12 ga.
54	ALS Technologies	Power Punch, Ballistic Bag (High)	$4.75	Available	Pad, Rectangle	12 ga.
55	ALS Technologies	Power Punch, Tail Stabilized	$4.75	Available	Drag-Stabilized	12 ga.
56	ALS Technologies	Hornets Nest .45 caliber	$16.00	Available	Pellets, Small	5"
57	ALS Technologies	Hornets Nest .69 caliber	$16.00	Available	Pellets, Large	5"
58	ALS Technologies	Tri-Dent	$15.50	Available	Pellets, Large	5"
59	ALS Technologies	Mono-Ball	$13.50	Available	Pellet, Single	2.5"
60	ALS Technologies	Power Punch, Ballistic Bag	$18.50	Available	Pad, Round	2.5"
61	MK Ballistics Systems	Flexible Baton-12, Close Range	$5.20	Available	Pad, Rectangle	12 ga.
62	MK Ballistics Systems	Flexible Baton-12 Standard	$5.20	Available	Pad, Rectangle	12 ga.
63	MK Ballistics Systems	Flexible Baton-12 Standard, Dye Marking	$5.20	Available	Pad, Rectangle	12 ga.
64	MK Ballistics Systems	Flexible Baton-12, Standard (Ithaca & SW)	$5.20	Available	Pad, Rectangle	12 ga.

ID	Manufacturer	Model	Retail Price ($U.S.)	Availability	Configuration	Cartridge Size
65	MK Ballistics Systems	Flexible Baton-12 MK II, Stabilized	$6.40	Available	Drag-Stabilized	12 ga.
66	MK Ballistics Systems	RB-1-FS Rubber Fin Stablized Baton	$4.99	Available	Fin-Stabilized	12 ga.
67	MK Ballistics Systems	RB-12 Rubber Buck Shot	$4.99	Available	Pellets, Small	12 ga.
69	MK Ballistics Systems	RB-2 Rubber Baton	$4.99	Available	Baton, Rubber	12 ga.
70	MK Ballistics Systems	Flexible Baton (Close Range)	$21.00	Available	Pad, Round	4"
71	MK Ballistics Systems	Flexible Baton (Low Impact)	$21.00	Available	Pad, Round	4"
72	MK Ballistics Systems	Flexible Baton (Standard)	$21.00	Available	Pad, Round	4"
73	MK Ballistics Systems	Flexible Baton (Multi-Flex)	$25.00	Available	Pad, Round	4"
74	MK Ballistics Systems	Multi Baton-Rubber	$20.00	Available	Baton, Rubber	8"
76	MK Ballistics Systems	Multi-Ball	$17.50	Available	Pellets, Large	8"
77	MK Ballistics Systems	RB-1-FS (Close Range)	$17.00	Available	Fin-Stabilized	8"
78	MK Ballistics Systems	RB-1-FS (Standard)	$17.00	Available	Fin-Stabilized	8"
79	MK Ballistics Systems	Flexible Baton, MK III, Stabilized	$18.00	Available	Drag Stabilized	8"
81	MK Ballistics Systems	Flexible Baton (Low Impact)	$18.00	Available	Pad, Round	3.25"
82	MK Ballistics Systems	Flexible Baton (Multiflex)	$18.00	Available	Pad, Round	3.25"
83	MK Ballistics Systems	Flexible Baton (Multi-Flex)	$22.00	Available	Pad, Round	3.25"
85	MK Ballistics Systems	Multi-Ball	$17.50	Available	Pellets, Large	5.5"
86	MK Ballistics Systems	Multi-Baton (Rubber)	$17.50	Available	Baton, Rubber	5.5"
87	MK Ballistics Systems	Multi-Baton (Foam)	$17.50	Available	Baton, Foam	5.5"
88	MK Ballistics Systems	5.56mm Multi-Ball	$4.00	Available	Pellets, Small	5.56mm
90	Edgewood & Guilford Engr.	Ring Airfoil Projectile	-	Emerging	Airfoil	5.56mm
91	Sage, Inc.	KO1	$18.30	Available	Baton, Plastic	4.8"
92	Sage, Inc.	KO1LE	$18.30	Available	Baton, Plastic	4.8"
97	Sage, Inc.	KO-3P	-	Emerging	baton, Stryofoam	4.8"
98	Sage, Inc.	KO-3LEP	-	Emerging	baton, Styrofoam	4.8"
99	Jaycor	Malodorant	-	Emerging	Encapsulated Projectile	.68 Caliber
100	Technical Solutions	Bean Bag	$3.80	Available	Pad, Rectangle	12 ga.
101	Technical Solutions	Rubber Fin Stabilized	$2.90	Available	Fin-Stabilized	12 ga.
102	Technical Solutions	Peace Keeper	$4.00	Available	Encapsulated Projectile	12 ga.
103	ALS Technologies	Power Punch, Tail Stabilized Pen-Prevent	-	Emerging	Drag Stabilized	12 ga.

Table 2.
MATERIAL, LAUNCHER, METHOD OF ENGAGEMENT, AND FIELD ID.

ID	Manufacturer	Model	Material	Launcher	Method of Engagement	Field ID
2	Defense Technologies	27A Stinger	Rubber	37mm	Direct or Skip Fired	Text
3	Defense Technologies	27B Stinger	Rubber	37mm	Direct or Skip Fired	Text
4	Defense Technologies	37A Stinger	Rubber	37/40mm	Direct or Skip Fired	Text
5	Defense Technologies	40A Stinger	Rubber	40mm	Direct or Skip Fired	Text
6	Defense Technologies	28A Stinger	Rubber	37mm	Direct or Skip Fired	Text
7	Defense Technologies	28B Stinger	Rubber	37mm	Direct or Skip Fired	Text
8	Defense Technologies	37B Stinger	Rubber	37/40mm	Direct or Skip Fired	Text
9	Defense Technologies	40B Stinger	Rubber	40mm	Direct or Skip Fired	Text
13	Defense Technologies	37F Foam Rubber Multiple Baton	Rubber-Foam	37/40mm	Direct Fired	Text
14	Defense Technologies	40F Foam Rubber Multiple Baton	Rubber-Foam	40mm	Direct Fired	Text
18	Defense Technologies	37BR-S Bean Bag	Silica	37/40mm	Direct Fired	Text
19	Defense Technologies	37BR-BP Bean Bag	Silica	37/40mm	Direct Fired	Text
20	Defense Technologies	40BR Bean Bag	Silica	40mm	Direct Fired	Text
21	Defense Technologies	Exact Impact 1006	Rubber-Foam	40mm	Direct Fired	Shape
22	Defense Technologies	23DS Drag Stabilized	Lead	Shotgun	Direct Fired	
23	Defense Technologies	23BR Bean Bag	Lead	Shotgun	Direct Fired	Text
28	Combined Tactical Systems	2552 Sting-Ball	Rubber	Shotgun	Direct or Skip Fired	Text
29	Combined Tactical Systems	2553 Sting Ball High Velocity	Rubber	Shotgun	Direct or Skip Fired	Text
30	Combined Tactical Systems	2581 Super-Sock	Lead	Shotgun	Direct Fired	Text
31	Combined Tactical Systems	3551 Foam Baton	Rubber-Foam	37/40mm	Direct Fired	Text
32	Combined Tactical Systems	3555 Foam Baton	Rubber-Foam	37/40mm	Direct Fired	Text
33	Combined Tactical Systems	3553 31 caliber Sting ball	Rubber	37/40mm	Direct or Skip Fired	Text
34	Combined Tactical Systems	3556 31 Caliber Sting Ball	Rubber	37/40mm	Direct or Skip Fired	Text
35	Combined Tactical Systems	3554 60 Caliber Sting Ball	Rubber	37/40mm	Direct or Skip Fired	Text
36	Combined Tactical Systems	3557 60 Caliber Sting Ball	Rubber	37/40mm	Direct or Skip Fired	Text
39	Royal Arms International	HN Hornet's Nest Rubber Buck	Rubber	Shotgun	Direct or Skip Fired	Text
40	Royal Arms International	BB-L Low Power	Lead	Shotgun	Direct Fired	Tactile/Visual
41	Royal Arms International	BB-M Medium Power	Lead	Shotgun	Direct Fired	Tactile/Visual
42	Royal Arms International	BB 12-H Heavy Power	Lead	Shotgun	Direct Fired	Tactile/Visual
43	Royal Arms International	FIN-12 Fin Stabilized Rubber Baton	Rubber	Shotgun	Direct Fired	Tactile/Visual
44	Jaycor	Pepperball - Pepper dust	Powder	Paintball	Direct Fired	Color/Shape
45	Jaycor	Pepperball - Liquid filled	Liquid	Paintball	Direct Fired	Color/Shape
47	Combined Tactical Systems	4557 Sponge Baton	Rubber-Foam	40mm	Direct Fired	Shape
48	Combined Tactical Systems	4551 Foam Baton	Rubber-Foam	40mm	Direct Fired	Text
49	Combined Tactical Systems	4553 .31 caliber Sting Ball	Rubber	40mm	Direct or Skip Fired	Text
50	Combined Tactical Systems	4554 .60 Caliber Sting Ball	Rubber	40mm	Direct or Skip Fired	Text
51	ALS Technologies	Hornets Nest	Rubber	Shotgun	Direct or Skip Fired	Visual
52	ALS Technologies	Tri-Dent	Rubber	Shotgun	Direct or Skip Fired	Visual
53	ALS Technologies	Rocket	Rubber	Shotgun	Direct Fired	Visual
54	ALS Technologies	Power Punch, Ballistic Bag (High)	Lead	Shotgun	Direct Fired	Visual
55	ALS Technologies	Power Punch, Tail Stabilized	Lead	Shotgun	Direct Fired	Visual
56	ALS Technologies	Hornets Nest .45 caliber	Rubber	37/40mm	Direct or Skip Fired	Text
57	ALS Technologies	Hornets Nest .69 caliber	Rubber	37/40mm	Direct or Skip Fired	Text
58	ALS Technologies	Tri-Dent	Rubber	37/40mm	Direct or Skip Fired	Text
59	ALS Technologies	Mono-Ball	Rubber	37/40mm	Direct or Skip Fired	Text/Shape
60	ALS Technologies	Power Punch, Ballistic Bag	Lead	37/40mm	Direct Fired	Text
61	MK Ballistics Systems	Flexible Baton-12, Close Range	Lead	Shotgun	Direct Fired	Visual
62	MK Ballistics Systems	Flexible Baton-12 Standard	Lead	Shotgun	Direct Fired	Visual
63	MK Ballistics Systems	Flexible Baton-12 Standard, Dye Marking	Lead	Shotgun	Direct Fired	Visual
64	MK Ballistics Systems	Flexible Baton-12, Standard (Ithaca & SW)	Lead	Shotgun	Direct Fired	Visual

ID	Manufacturer	Model	Material	Launcher	Method of Engagement	Field ID
65	MK Ballistics Systems	Flexible Baton-12 MK II, Stabilized	Lead	Shotgun	Direct Fired	Visual
66	MK Ballistics Systems	RB-1-FS Rubber Fin Stablized Baton	Rubber	Shotgun	Direct Fired	Visual
67	MK Ballistics Systems	RB-12 Rubber Buck Shot	Rubber	Shotgun	Direct or Skip Fired	Visual
69	MK Ballistics Systems	RB-2 Rubber Baton	Rubber	Shotgun	Direct Fired	Visual
70	MK Ballistics Systems	Flexible Baton (Close-Range)	Lead	37mm Launcher	Direct Fired	Text
71	MK Ballistics Systems	Flexible Baton (Low-Impact)	Lead	37mm Launcher	Direct Fired	Text
72	MK Ballistics Systems	Flexible Baton (Standard)	Lead	37mm Launcher	Direct Fired	Text
73	MK Ballistics Systems	Flexible Baton (Multiflex)	Lead	37mm Launcher	Direct Fired	Text
74	MK Ballistics Systems	Multi-Baton Rubber	Rubber	37mm Launcher	Direct Fired	Text
76	MK Ballistics Systems	Multi-Ball	Rubber	37mm Launcher	Direct or Skip Fired	Text
77	MK Ballistics Systems	RB-1-FS (Close Range)	Rubber	37mm Launcher	Direct Fired	Text
78	MK Ballistics Systems	RB-1-FS (Standard)	Rubber	37mm Launcher	Direct Fired	Text
79	MK Ballistics Systems	Flexible Baton, MK III, Stabilized	Steel	37mm Launcher	Direct Fired	Text
81	MK Ballistics Systems	Flexible Baton (Low-Impact)	Lead	40mm Launcher	Direct Fired	Text
82	MK Ballistics Systems	Flexible Baton (Multiflex)	Lead	40mm Launcher	Direct Fired	Text
83	MK Ballistics Systems	Flexible Baton (Multiflex)	Lead	40mm Launcher	Direct Fired	Text
85	MK Ballistics Systems	Multi-Ball	Rubber	40mm Launcher	Direct or Skip Fired	Text
86	MK Ballistics Systems	Multi-Baton (Rubber)	Rubber	40mm Launcher	Direct Fired	Text
87	MK Ballistics Systems	Multi-Baton (Foam)	Rubber-Foam	40mm Launcher	Direct Fired	Text
88	MK Ballistics Systems	5.56mm Multi-Ball	Rubber	Rifle	Direct Fired	Color
90	Edgewood & Guilford Engr.	Ring Airfoil Projectile	Rubber	Special	Direct Fired	Shape
91	Sage, Inc.	KO1	Plastic	37mm Launcher	Direct Fired	Text/Shape
92	Sage, Inc.	KO1LE	Plastic	37mm Launcher	Direct Fired	Text/Shape
97	Sage, Inc.	KO-3P	Styrofoam	37mm Launcher	Direct Fired	Text
98	Sage, Inc.	KO-3LEP	Styrofoam	37mm Launcher	Direct Fired	Text
99	Jaycor	Malodorant	Liquid	Paintball	Direct Fired	Color/Shape
100	Technical Solutions	Bean Bag	Lead	Shotgun	Direct Fired	Text
101	Technical Solutions	Rubber Fin-Stabilized	Rubber	Shotgun	Direct Fired	Text
102	Technical Solutions	Peace Keeper	Liquid	Shotgun	Direct Fired	Text
103	ALS Technologies	Power Punch, Tail Stabilized Pen-Prevent	Lead	Shotgun	Direct Fired	Text

Table 3.
DISPERSION AND IMPARTED MOMENTUM.

ID	Manufacturer	Model	Dispersion at 21' (in.)	Imparted Momentum at 21' (Ns)	Accuracy at 75' (in.)	Imparted Momentum at 75' (in.)
2	Defense Technologies	27A Stinger	42.5	6.07		
3	Defense Technologies	27B Stinger	25.5	5.79		
4	Defense Technologies	37A Stinger	27	4.88		
5	Defense Technologies	40A Stinger	32	5.28		
6	Defense Technologies	28A Stinger	36	3.85		
7	Defense Technologies	28B Stinger	34	6.97		
8	Defense Technologies	37B Stinger	16	4.68		
9	Defense Technologies	40B Stinger	23	5.41		
13	Defense Technologies	37F Foam Rubber Multiple Baton	36	2.7		
14	Defense Technologies	40F Foam Rubber Multiple Baton	25	2.83		
18	Defense Technologies	37BR-S Bean Bag	11.5	5.96	21	4.06
19	Defense Technologies	37BR-BP Bean Bag	6	4.79		
20	Defense Technologies	40BR Bean Bag	5	5.58	24	4.85
21	Defense Technologies	Exact Impact 1006	9	2.9	5	2.56
22	Defense Technologies	23DS Drag Stabilized	3	3.37	6.5	2.71
23	Defense Technologies	23BR Bean Bag	3.5	3	19.5	2.17
28	Combined Tactical Systems	2552 Sting-Ball	26.5	1.11		
29	Combined Tactical Systems	2553 Sting Ball High Velocity	31	1.84		
30	Combined Tactical Systems	2581 Super-Sock	3	2.84	10.5	2.14
31	Combined Tactical Systems	3551 Foam Baton	39	1.94		
32	Combined Tactical Systems	3555 Foam Baton	37	2.41		
33	Combined Tactical Systems	3553 31 caliber Sting ball	22	5.54		
34	Combined Tactical Systems	3556 31 Caliber Sting Ball	47	8.81		
35	Combined Tactical Systems	3554 60 Caliber Sting Ball	27	3.32		
36	Combined Tactical Systems	3557 60 Caliber Sting Ball	38	6.6		
39	Royal Arms International	HN Hornet’s Nest Rubber Buck	5.5	0.96		
40	Royal Arms International	BB-L Low Power	4	2.15	36+	1.7
41	Royal Arms International	BB-M Medium Power	4	1.98	14	1.79
42	Royal Arms International	BB 12-H Heavy Power	3	3.6	36+	3.68
43	Royal Arms International	FIN-12 Fin Stabilized Rubber Baton	3	1.56	15	0.99
44	Jaycor	Pepperball - Pepper dust	7	0.11		
45	Jaycor	Pepperball - Liquid filled	5	0.127		
47	Combined Tactical Systems	4557 Sponge Baton	3.5	5.46	10	5.66
48	Combined Tactical Systems	4551 Foam Baton	44	6.04		
49	Combined Tactical Systems	4553 .31 caliber Sting Ball	46	5.47		
50	Combined Tactical Systems	4554 .60 Caliber Sting Ball	29	3.86		
51	ALS Technologies	Hornets Nest	29	0.83		
52	ALS Technologies	Tri-Dent	11.5	1.45		
53	ALS Technologies	Rocket	3	2.15	8.5	1.65
54	ALS Technologies	Power Punch, Ballistic Bag (High)	3.5	3.51	25	2.29
55	ALS Technologies	Power Punch, Tail Stabilized	5	3.27	19	2.24
56	ALS Technologies	Hornets Nest .45 caliber	28	5.91		
57	ALS Technologies	Hornets Nest .69 caliber	21.5	5.95		
58	ALS Technologies	Tri-Dent	25	8.22		
59	ALS Technologies	Mono-Ball	5.5	4.25	36+	3
60	ALS Technologies	Power Punch, Ballistic Bag	10	3.69	36+	2.84
61	MK Ballistics Systems	Flexible Baton-12, Close Range	2.5	2.42	30.5	2.25
62	MK Ballistics Systems	Flexible Baton-12 Standard	3.5	2.95	12	2.95
63	MK Ballistics Systems	Flexible Baton-12 Standard, Dye Marking	4	2.9	18.5	2.58
64	MK Ballistics Systems	Flexible Baton-12, Standard (Ithaca & SW)	3	3.36	9.5	2.94

ID	Manufacturer	Model	Dispersion at 21' (in.)	Imparted Momentum at 21' (Ns)	Accuracy at 75' (in.)	Imparted Momentum at 75' (in.)
65	MK Ballistics Systems	Flexible Baton-12 MK II, Stabilized	3.75	2.79	24.5	1.98
66	MK Ballistics Systems	RB-1-FS Rubber Fin Stablized Baton	4	1.06	7.5	0.56
67	MK Ballistics Systems	RB-12 Rubber Buck Shot	9	1.23		
69	MK Ballistics Systems	RB-2 Rubber Baton	3	1.99		
70	MK Ballistics Systems	Flexible Baton (Close-Range)	11	6.94	36+	6.65
71	MK Ballistics Systems	Flexible Baton (Low-Impact)	6	7.21	15	7.62
72	MK Ballistics Systems	Flexible Baton (Standard)	4	7.97	36+	5.62
73	MK Ballistics Systems	Flexible Baton (Multiflex)	12	7.11		
74	MK Ballistics Systems	Multi Baton-Rubber	13	11.09		
76	MK Ballistics Systems	Multi-Ball	45	7.08		
77	MK Ballistics Systems	RB-1-FS (Close-Range)	2.5	4.26	21.5	3.82
78	MK Ballistics Systems	RB-1-FS (Standard)	5	5.62	19.5	4.38
79	MK Ballistics Systems	Flexible Baton, MK III, Stabilized	3.5	6.21	25.5	5.48
81	MK Ballistics Systems	Flexible Baton (Low-Impact)	4	6.79	23.5	6.83
82	MK Ballistics Systems	Flexible Baton (Multiflex)	13.5	10.8	14.5	8.21
83	MK Ballistics Systems	Flexible Baton (Multiflex)	9	8.27	36+	4.85
85	MK Ballistics Systems	Multi-Ball	31	6.38		
86	MK Ballistics Systems	Multi-Baton (Rubber)	15	9.58		
87	MK Ballistics Systems	Multi-Baton (Foam)	16	3.06		
88	MK Ballistics Systems	5.56mm Multi-Ball	8.5	0.406		
90	Edgewood & Guilford Engr.	Ring Airfoil Projectile	3.5	2.17	36+	1.96
91	Sage, Inc.	KO1	10.5	6.43	11	5.93
92	Sage, Inc.	KO1LE	6	4.25	16	4.32
97	Sage, Inc.	KO-3P	4	5.81		
98	Sage, Inc.	KO-3LEP	3.5	4.32		
99	Jaycor	Malodorant	9.5	0.09		
100	Technical Solutions	Bean Bag	5	3.81	36+	3.22
101	Technical Solutions	Rubber Fin Stabilized	10	1.59	9.5	1.11
102	Technical Solutions	Peace Keeper	4	2.35	5	1.67
103	ALS Technologies	Power Punch, Tail Stabilized Pen-Prevent	4	2.94	16	2.19

Table 4.
WEIGHT, PROJECTILES, AND SPECIAL FEATURES.

ID	Manufacturer	Model	Weight (g)	Projectiles	Special Features
2	Defense Technologies	27A Stinger	0.42	175	
3	Defense Technologies	27B Stinger	0.41	225	
4	Defense Technologies	37A Stinger	0.41	125	
5	Defense Technologies	40A Stinger	0.42	150	
6	Defense Technologies	28A Stinger	3.33	27	
7	Defense Technologies	28B Stinger	3.34	42	
8	Defense Technologies	37B Stinger	2.45	24	
9	Defense Technologies	40B Stinger	2.51	24	
13	Defense Technologies	37F Foam Rubber Multiple Baton	10.44	3	
14	Defense Technologies	40F Foam Rubber Multiple Baton	8.64	3	
18	Defense Technologies	37BR-S Bean Bag	96.6		
19	Defense Technologies	37BR-BP Bean Bag	96.3	1	
20	Defense Technologies	40BR Bean Bag	95.96	1	
21	Defense Technologies	Exact Impact 1006	29.74	1	
22	Defense Technologies	23DS Drag Stabilized	38.55	1	Multi-tail drag-stabilized
23	Defense Technologies	23BR Bean Bag	38.66	1	
28	Combined Tactical Systems	2552 Sting-Ball	0.42	18	
29	Combined Tactical Systems	2553 Sting Ball High Velocity	0.42	18	
30	Combined Tactical Systems	2581 Super-Sock	39.53	1	
31	Combined Tactical Systems	3551 Foam Baton	9.73	3	
32	Combined Tactical Systems	3555 Foam Baton	8.97	5	
33	Combined Tactical Systems	3553 31 caliber Sting ball	0.42	180	
34	Combined Tactical Systems	3556 31 Caliber Sting Ball	0.42	300	
35	Combined Tactical Systems	3554 60 Caliber Sting Ball	1.75	24	
36	Combined Tactical Systems	3557 60 Caliber Sting Ball	1.79	42	
39	Royal Arms International	HN Hornet's Nest Rubber Buck	6	21	
40	Royal Arms International	BB-L Low Power	28	1	Thin film reduces friction and protects projectiles
41	Royal Arms International	BB-M Medium Power	28	1	Thin film reduces friction and protects projectiles
42	Royal Arms International	BB 12-H Heavy Power	49	1	Thin film reduces friction and protects projectiles
43	Royal Arms International	FIN-12 Fin Stabilized Rubber Baton	7	1	
44	Jaycor	Pepperball - Pepper dust	1.91	1	Contains micro-pulverized "pepper dust"
45	Jaycor	Pepperball - Liquid filled	2.59	1	Liquid - can be malodorant, dye marker, etc.
47	Combined Tactical Systems	4557 Sponge Baton	60.89	1	
48	Combined Tactical Systems	4551 Foam Baton	24.1	3	
49	Combined Tactical Systems	4553 .31 caliber Sting Ball	0.41	300	
50	Combined Tactical Systems	4554 .60 Caliber Sting Ball	2.44	24	
51	ALS Technologies	Hornets Nest	0.28	21	
52	ALS Technologies	Tri-Dent	7.81	1	
53	ALS Technologies	Rocket	9.19	1	
54	ALS Technologies	Power Punch, Ballistic Bag (High)	41.11	1	
55	ALS Technologies	Power Punch, Tail Stabilized	39.45	1	
56	ALS Technologies	Hornets Nest .45 caliber	0.0064	60	
57	ALS Technologies	Hornets Nest .69 caliber	2.63	15	
58	ALS Technologies	Tri-Dent	24.25	3	
59	ALS Technologies	Mono-Ball	24.15	1	
60	ALS Technologies	Power Punch, Ballistic Bag	100.19	1	
61	MK Ballistics Systems	Flexible Baton-12, Close Range	39.62	1	
62	MK Ballistics Systems	Flexible Baton-12 Standard	39.5	1	
63	MK Ballistics Systems	Flexible Baton-12 Standard, Dye Marking	38.66	1	Contains yellow dye marker; transferred on impact
64	MK Ballistics Systems	Flexible Baton-12, Standard (Ithaca & SW)	38.65	1	Designed for Ithaca 37 and S&W 3000 shotguns

ID	Manufacturer	Model	Weight (g)	Projectiles	Special Features
65	MK Ballistics Systems	Flexible Baton-12 MK II, Stabilized	39.46	1	Drag stabilized
66	MK Ballistics Systems	RB-1-FS Rubber Fin Stablized Baton	6.21	1	
67	MK Ballistics Systems	RB-12 Rubber Buck Shot	0.54	12	
69	MK Ballistics Systems	RB-2 Rubber Baton	6.07	2	
70	MK Ballistics Systems	Flexible Baton (Close Range)	149.8	1	
71	MK Ballistics Systems	Flexible Baton (Low Impact)	150.05	1	
72	MK Ballistics Systems	Flexible Baton (Standard)	150.41	1	
73	MK Ballistics Systems	Flexible Baton (Multi-Flex)	38.31	4	
74	MK Ballistics Systems	Multi Baton-Rubber	37.68	5	
76	MK Ballistics Systems	Multi-Ball	2.2	42	
77	MK Ballistics Systems	RB-1-FS (Close Range)	73.14	1	
78	MK Ballistics Systems	RB-1-FS (Standard)	74.38	1	
79	MK Ballistics Systems	Flexible Baton, MK III, Stabilized	85.63	1	
81	MK Ballistics Systems	Flexible Baton (Low Impact)	148.75	1	
82	MK Ballistics Systems	Flexible Baton (Multiflex)	39.42	5	
83	MK Ballistics Systems	Flexible Baton (Multi-Flex)	149.39	1	
85	MK Ballistics Systems	Multi-Ball	2.18	28	
86	MK Ballistics Systems	Multi-Baton (Rubber)	39.02	3	
87	MK Ballistics Systems	Multi-Baton (Foam)	8.8	3	
88	MK Ballistics Systems	5.56mm Multi-Ball	1.04	5	
90	Edgewood & Guilford Engr.	Ring Airfoil Projectile	34.31	1	Uses airfoil as projectile/chemical agent delivery
91	Sage, Inc.	KO1	75	1	
92	Sage, Inc.	KO1LE	75	1	
97	Sage, Inc.	KO-3P	72	1	
98	Sage, Inc.	KO-3LEP	72	1	
99	Jaycor	Malodorant	1.84	1	
100	Technical Solutions	Bean Bag	39	1	
101	Technical Solutions	Rubber Fin Stabilized	7	1	
102	Technical Solutions	Peace Keeper	11	1	Uses soft-rubber, liquid-filled projectile
103	ALS Technologies	Power Punch, Tail Stabilized Pen-Prevent	38.9	1	