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Evaluation of Beanbag Munitions and Launchers

A report to the National Institute of Justice

CHARLIE MESLOH, PhD
Associate Professor, Florida Gulf Coast University

LINDSEY MEDLEY, MPA
Graduate Research Assistant

JO ANN WERBALIS, B.S
Graduate Research Assistant

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PURPOSE, GOALS, AND OBJECTIVES

This project examined three of the predominant in-service 12 gauge beanbag munitions, produced by AMTEC Less-Lethal Systems (ALS), Combined Tactical System (CTS), and Defense Technology (Def-Tech). These rounds were tested and the results standardized across five different shotgun launchers. Two of these launchers were semi-automatic and possessed the ability to properly cycle beanbag ammunition (which is a major advancement in less lethal technology). The following process objectives detail the proposed objectives in comparing the aforementioned less lethal munitions.

Objective 1: Comparison of projectile velocity for each brand of munitions in each launcher.

Objective 2: Detailed analysis of accuracy rates as quantified through drop, drift and spread of the projectiles at predetermined distances.

Objective 3: Identify common malfunctions, vulnerabilities, and determine the functionality of the five shotgun launchers.

LITERATURE REVIEW

Frequently law enforcement officers are faced with armed or resisting offenders who refuse to comply with lawful commands. Consequently, a degree of force on the part of law enforcement officer or agent is necessary to bring the situation to a peaceful resolution. Unfortunately to date, there is no less lethal weapon than fits every circumstance.

Over the last five years, the Weapons and Equipment Research Institute has tested and evaluated the spectrum of less lethal technology currently in use by law enforcement agencies around the country. A significant problem for law enforcement agencies that are preparing to deploy less lethal weapons into the field is that they are required to rely on factory data, specification sheets, and company marketing in order to make the critical decision as to which system to adopt. Our goal has been to provide an independent review to allow comparison across the different types of weapons and allow agencies the ability to make better informed decisions.

While some options like the TASER® appear to offer the maximum in suspect compliance benefits and a reduction in both suspect and officer injuries, they are limited by the range[1] that they can reach a suspect and the number of suspects that can be immediately engaged. Impact weapons and batons have a low success rate (45%) and frequently lead to an escalation of the suspect's resistance (Mesloh, Wolf, Henych, & Thompson, 2007). Chemical agents, such as Oleoresin Capsicum (OC) spray and launched chemical munitions are more effective but the onset of effects are not instantaneous and suspects have been known to fight through the burning pain.

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[1] The majority of successful TASER® deployments tend to occur at less than fifteen feet (Mesloh, Henych, & Wolf, 2007).

While these technologies have the potential to be a very effective tool for incapacitating suspects, they often require the officers to place themselves within the Reactionary Gap where they are at substantially more risk of injury. Based upon the prior studies, the 12 gauge beanbag munitions shows the capability of delivering incapacitating payloads to greater distances than that of other tools in the less lethal category (Mesloh, Thompson, Wargo, Collie, & Berry, 2008).

Impact Munitions

Less lethal impact munitions generally fire a projectile(s) that provide a transfer of kinetic energy that will impact and potentially incapacitate a suspect. Beanbag projectiles have tremendous utility at greater distances but they tend to suffer the limitation of transferring too much kinetic force energy when applied at closer ranges. The projectiles are intended to impart a significant amount of kinetic energy without penetrating the targets body (Bozeman, 2005).

A number of deaths and serious injuries have been documented from kinetic energy weapons at various close ranges. Harder projectiles and those with more mass were found to result in higher injury rates (DuBay and Bir, 2000). Beanbag injury records rang from minor bruising and swelling of the impacted area to more severe cases such as, rectus sheath hematoma, liver laceration, abdominal wall contusion, and scalp de-gloving injury and post-concussive syndrome (Suyama, Sztajnkrycer, FitzGerald, & Barnes, 2003).

As the range that these munitions are used is increased, the rate of injury tends to drop off sharply (Hubbs, & Klinger, 2004; (Chowaniec, Jabłonski, Kabiesz-Neniczka, & Karczewska, 2008) and is likely a result of a reduction in velocity at greater distances. According to manufacturers' specification sheets, the standard beanbag projectiles leave the barrel at 260- 300 feet per second (fps). Shortly before this study, we chronograph measured a beanbag at 860 fps.

This represents an increase in kinetic energy by a factor of eight or nine and would potentially transfer a lethal amount of force into a suspect. It is hypothesized that this type of anomaly might explain the some of the unexplained fatal applications of this technology.

Several studies have illustrated the poor aerodynamics of these projectiles due to their large surface area. A study conducted by Wayne State University (2011), assessed that there is a great deal of disparity in beanbag design with no two rounds behaving in the exact same manner during flight. It was found that even when two rounds of the same type were fired in the same manner different shot placements were a result. This can cause increases in the accidental striking of unintended areas of the body or missing the target entirely (Bozeman, 2005). It becomes a dangerous balancing act in determining the weapon that has sufficient energy to incapacitate, while at the same time not killing the recipient. Equally problematic is the selection of a weapons system that is sufficiently portable for patrol officers to bring to bear in the field with relative ease of carry.

Launchers

While different launchers and projectiles are on the market with many projectiles existing to fit the specific need of the individual scenario, the 12 gauge shotgun launcher is most frequently utilized, as most agencies already possess at the very least one shotgun. In the past, it has been recognized that 12 gauge less lethal munitions must be fired from a pump action shotgun in order for the ammunition to cycle correctly (Kenny, Heal and Grossman, 2001: Hubbs and Klinger, 2004). While advances in firearms technology have produced a number of semi-auto and full-auto shotguns for tactical operations, the majority of semi-auto shotguns are still unlikely to be capable of cycling less lethal ammunition (although two shotguns were identified for this study that possessed this ability).

Using a single brand of beanbag rounds, Mesloh and Thompson (2006) tested the drop rates of the projectiles at distances up to forty feet and found that the drop was approximately 3.78 inches. Beyond forty feet, the accuracy of the rounds began decreasing and their flight became more erratic. At increasing distances, the risk of striking a non-targeted region of the suspect's body during a deployment increases. However, this analysis utilized a single Remington 870 shotgun and substantial variability in projectile drop and spread was noted when other shotgun systems were comparatively tested.

A second study of beanbag projectiles (N=480) was conducted utilizing the Remington 870 Modular Shotgun System and its three associated barrels (10 in, 14 in, 18 in). Barrel length was found to directly impact the accuracy of the weapon beyond 60 feet with shorter barrels exhibiting a greater variance in beanbag accuracy (Mesloh, et al., 2008).

There are a number of highly technical studies that have focused on the impact of kinetic energy based less lethal weapons (DuBay and Bir, 2000; Hubbs and Klinger, 2004; Kenny et al. 2008; Wayne State University, 2011). This research will continue to build on the methodologies and findings of previous research to determine accuracy rates of a number of less lethal munitions and various launchers.

METHODOLOGY

Research Design and Method

A multifaceted approach was used to conduct this study, which included a controlled data collection effort (on an indoor firing range) and a qualitative assessment of each weapon. The research design was created to measure the overall performance of the three (3) brands of ammunition and the five (5) shotguns being tested at ten-foot intervals, ranging from ten feet (10') to ninety feet (90'). The primary goal was to identify accuracy, velocity, reliability, and any malfunctions presented.

One of the major concerns of the study focused upon the balancing of internal and external validity. Prior studies tended to emphasize internal validity by utilizing universal receiver type launchers that have the capability of remote fire with the intent to totally remove shooter error. Unfortunately, this has the unintended consequence of negatively impacting the external validity as it has been documented that each shotgun system produces substantially different results. As a result, it was decided that multiple shotgun systems would be incorporated into the study. Findings are easily generalizable given that two control weapons represent the overwhelming majority of law enforcement shotguns currently in service. The size of this sample is large enough and has sufficient statistical power to ensure (internal) reliability for regression analysis of the projectile drop and drift.

Data was collected from each shot from a fixed-position firing platform (modified Ransom rest) from the shooter, and statistical tests (reliability coefficients) and used to create predictive models for each of the weapons systems at the various distance intervals. Accuracy was measured through the spread of all of the fired projectiles at a given distance and the difference between the point of aim (POA) and the point of impact (POI) for each projectile. Measurements and photographs were taken after the shooter fired the rounds from each of the munitions at each distance. As it has been documented that the 12 gauge less lethal munitions tend to foul the weapon, the shotguns will be cleaned at the conclusion of fire for each distance.

The point of aim was standardized by utilizing a neon orange stick-on target. This point of aim was not modified between test firings or distances. Each target was marked by distance, then brand of ammunition used, and gun used. Additionally, each brand of ammunition was tested and data was collected on its own target by distance and gun. The targets were then classified into two working groups: *pump action shotguns* and *semi-automatic shotguns*. The Remington 870, Mossberg 500, and the Kel-Tec KSG data were collected on one target for the *pump action shotguns*, while the SRM-1216 and Saiga-12 were collected on a separate target for the *semi-automatic shotguns*. Data from a total of 840 test firings was collected in this stage of the project.

Data Collection, Measurement and Analysis

The project fired the 12 gauge beanbag munitions from a fixed platform at increasingly greater distances. Five (5) different brands of shotguns were used in testing and evaluation (see appendix A for full description and features of each weapon system). The Remington 870 pump action is the most commonly used shotgun by law enforcement, while the Mossberg 500 pump action is the most commonly used shotgun by the military. These two shotguns were utilized as controls throughout testing as their reliability has been tested in several previous studies.

Three (3) experimental or pre-production shotguns were tested and evaluated: Saiga-12, Kel-Tec's KSG and SRM-1216. The Saiga-12 is produced by Izhmash (a Russian weapons manufacturer) and is a semi-automatic shotgun specifically modified by Cadiz Gun Works to fire less lethal beanbag ammunition and comes with five (5) or ten (10) round detachable magazines. However, the standard Saiga-12 is not capable of cycling less lethal munitions.

The KSG is Kel-Tec's first shotgun and utilizes a 12 gauge bull-pup design pump action with twin magazine tubes that house seven (7) rounds in each tube for a total of fourteen (14) rounds with a selector switch that allows the shooter to switch between the two magazine tubes. This shotgun was added to the study at the last minute due to its recent entrance into the firearms market and its potential as a light-weight, high capacity weapon.

The SRM-1216 is produced by SRM arms which is a semi-automatic shotgun designed to shoot game loads, trap loads, slugs, buck shot, and other specialty loads. In this case, specialty loads refer to less lethal beanbag rounds which require a special bolt that is not standard with the firearm. It utilizes a sixteen (16) round detachable magazine; four (4) magazine tubes each with a four (4) round capacity.

Three (3) different brands of ammunition used in this study; Combined Tactical System (CTS) model 2581 super-sock beanbag, AMTEC Less-Lethal Systems (ALS) triton tail stabilized beanbag, and Defense Technology (Def-Tech) 3027 drag stabilized beanbag . These specific brands and models were chosen due to their popularity for use by police officers and their predominance in the law enforcement marketplace. Shown in Figure 1 are the three brands chosen for this study, from left to right Def Tech, ALS, and CTS.

Figure 1. Beanbags Tested

Velocity

The beanbag's velocity after it was fired from each of the launchers was measured by a chronograph and was recorded using a spread sheet and video recording. The chronograph was placed two feet in front of the fixed-position firing platform (modified Ransom rest). The velocity was then analyzed by using Statistical Package for the Social Sciences (SPSS). Data from a total of 1,020 test firings was collected in this stage of the project.

Accuracy

Accuracy was measured as the difference between the point of aim (POA) and the point of impact (POI) in order to assess the elevation, and maximum spread of the projectiles. The center of the shot grouping was identified by using the average group radius method. This is done by locating the drift of the projectile that was farthest to the left of the POA and obtaining the average of all the shots from this distance on the horizontal plane. The elevation was found by locating the lowest shot from the POA and obtaining the average of all the shots from this distance on the vertical plane. These two averages identified the center of the group and from this point the average distance of each shot was determined, giving the mean radius of the shots. This shows the accuracy of all of the shots within the group and this procedure was done on each target for each shotgun and each brand of ammunition. The greatest strength of this method was its ability to view the distribution of the grouping as a whole while evaluating to performance of each individual shot. Drop was measured by how far the center of the group measured from the point of aim.

The second method was then utilized to further quantify accuracy. Maximum spread or extreme spread was measured to determine distance between the two furthest shots of the shot pattern or grouping. This is a less accurate (but popular) method of measuring the group size and does not provide a valid measure of central tendency for statistical analysis.

Distance Intervals

At each distance, five (5) shots were fired from each of the control weapons (Remington 870 and the Mossberg 500), ten (10) shots fired from the KSG, SRM-1216 and Saiga-12. A total 840 beanbag rounds were fired in this stage of the project. Targets consisted of one sheet of 8x4 piece of corrugated cardboard stapled to a target stand for distances 90ft to 60ft and was capable of capturing the greatest amount of data regardless of the drift and spread of projectiles. At closer distances, it was possible to use a much smaller torso type target (type) and collect the same level of data. Data was acquired in this phase by measuring the distances in inches and then entering the data into SPSS (Statistical Package for the Social Sciences) so that statistical analysis was conducted. The below table describes the key variables of this study.

Table 1. Key Variables and Measurement

Variable	Description
Projectile Accuracy	Mean Radius, Center of Group and Drop
Projectile Spread	Distance between projectiles (Maximum spread)
Projectile Velocity	Chronograph (FPS)
Reliability	Continues to function without failure
Malfunctions	Magazine issues, failed to cycle, failed to fires

Training

The training of project staff was conducted by the principle investigator who held numerous less lethal instructor certifications including impact munitions. All personnel were certified as end-users and as a group fired in excess of 1,000 live rounds prior to engaging this project. As a result, each team member was extremely familiar with all five weapon systems and actively developed the methodology based upon prior experiences and observations.

FINDINGS

The initial testing focused upon the velocity of the beanbag projectiles (n = 1020). Although some variance was expected between weapons and different ammunition brands, it was originally hoped that projectile velocity would remain relatively constant within each specific brand to allow predictive modeling and the creation of trajectory tables. However, as shown in Table 2, a considerable variance was present within each brand even when fired from the same weapon.

Table 2. Beanbag Projectile Velocities

Beanbag Velocities by Ammunition and Launcher

Velocity

Ammo	Weapon	N	Minimum	Maximum	Mean	Std. Deviation
CTS	Remington 870	50	184.30	310.20	285.7860	21.06925
	Mossberg 500	50	214.30	588.60	312.4120	70.09141
	Kel-Tec KSG	80	205.70	317.10	287.8650	18.42160
	Saiga-12	80	212.70	378.60	259.5088	20.13933
	SRM -1216	80	169.70	330.00	306.5787	18.37619
	Total	340	169.70	588.60	288.9003	37.24784
ALS	Remington 870	50	220.50	403.20	311.0264	33.48186
	Mossberg 500	50	234.50	353.20	313.4160	26.28906
	Kel-Tec KSG	80	185.70	357.00	311.4450	27.23491
	Saiga-12	80	214.50	301.50	272.7975	15.46116
	SRM-1216	80	247.30	370.10	324.7025	18.64794
	Total	340	185.70	403.20	305.6992	30.54465
Def Tech	Remington 870	50	192.20	293.80	259.6920	23.28436
	Mossberg 500	50	204.80	324.50	270.6620	18.50148
	Kel-Tec KSG	80	170.40	300.30	272.6025	21.31033
	Saiga-12	80	150.00	293.20	235.9825	21.20621
	SRM-1216	80	211.10	369.70	288.3813	17.93913
	Total	340	150.00	369.70	265.5147	27.63042
Total	Remington 870	150	184.30	403.20	285.5015	33.69175
	Mossberg 500	150	204.80	588.60	298.8300	48.52855
	Kel-Tec KSG	240	170.40	357.00	290.6375	27.63744
	Saiga-12	240	150.00	378.60	256.0962	24.38055
	SRM-1216	240	169.70	370.10	306.5542	23.53148
	Total	1020	150.00	588.60	286.7047	36.02402

Fired beanbags were collected from the target area and sorted by manufacturer. These groups were repeatedly sampled and weighed. Statistical analysis indicated that there was no significant difference in the weights within each brand of beanbag (although there were differences between the manufactured brands). Further, statistical analysis between beanbag velocity and the projectile's weight indicated that no significant relationship was present. It is hypothesized that variances in the amount of propellant in each shell play a major role in projectile velocities (although this was not confirmed). Irregular projectile shapes (discussed in qualitative analysis) did not appear to affect initial velocity while dramatically impacting the accuracy at greater distances. However, the velocity was measured immediately after the beanbag left the barrel and the effect of the additional drag created by irregular or malfunctioning projectiles may not have been measurable at that distance.

Accuracy

There are a wide range of factors that influence the performance of any type of high velocity projectile. While our lab setting allowed this project to control for barrel length, temperature, humidity, barometric pressure, and wind velocity, it was impossible to control for factors created in the manufacturing process. Consequently, irregularities in the shapes of projectiles, variances in the amount of propellant and the specific characteristics of each weapon system were not constant and directly impacted the trajectory and accuracy of the beanbag during flight. Each brand of ammunition is predictable (to some degree) provided that both the weapon and the beanbag projectile are functioning properly but even slight irregularities have the potential to create substantial trajectory deviations at greater distances and vary by manufacturer. Additionally, each of the shotguns produced substantially different spreads and drop rates across each of the tested distances (shown in Tables 3 & 4). Consequently, it would be almost impossible to predict the trajectory of a beanbag projectile without controlling for the effect of the weapon and the ammunition as well as their interaction together.

Table 3. Extreme Spread and Mean Radius by Ammunition and Launcher

	Distance	CTS		ALS		Def Tech	
		E.S.	M.R.	E.S.	M.R.	E.S.	M.R.
30 ft.	Remington 870	4.00	1.40	6.25	2.50	4.00	1.85
	Mossberg 500	2.75	1.10	3.50	1.70	3.75	1.65
	Kel-Tec KSG	2.75	1.00	4.50	1.53	3.00	0.83
	Saiga-12	4.75	1.47	7.25	2.45	5.25	0.95
	SRM-1216	3.50	1.10	3.75	1.60	3.00	0.78
40 ft.	Remington 870	5.00	2.10	6.50	1.85	4.00	1.50
	Mossberg 500	4.25	1.70	4.25	2.05	3.75	1.75
	Kel-Tec KSG	4.75	1.88	9.00	2.70	3.25	0.95
	Saiga-12	5.25	1.42	10.50	2.45	3.75	1.35
	SRM-1216	4.25	1.27	6.75	2.50	3.50	0.73
50 ft.	Remington 870	7.00	2.95	9.75	3.35	4.50	1.65
	Mossberg 500	5.50	2.55	11.75	4.95	7.00	2.00
	Kel-Tec KSG	10.00	2.50	13.25	4.65	6.75	1.58
	Saiga-12	6.50	2.82	8.75	3.07	5.25	2.40
	SRM-1216	8.25	2.50	11.50	4.10	8.25	2.30
60 ft.	Remington 870	9.75	2.60	11.75	4.65	7.25	3.00
	Mossberg 500	10.50	3.85	20.25	7.85	6.50	2.35
	Kel-Tec KSG	11.75	2.95	20.75	6.63	5.50	1.68
	Saiga-12	12.00	3.69	11.00	3.80	6.75	2.65
	SRM-1216	10.75	4.30	12.50	4.60	7.50	2.40
70 ft.	Remington 870	6.75	2.55	10.75	3.70	9.00	2.60
	Mossberg 500	11.75	4.10	20.00	3.90	6.00	2.15
	Kel-Tec KSG	7.50	2.65	21.25	8.18	9.75	3.45
	Saiga-12	16.50	4.25	12.50	3.40	9.00	2.70
	SRM-1216	15.50	3.68	23.25	7.38	9.00	2.48
80 ft.	Remington 870	17.00	6.85	16.00	2.85	9.75	3.45
	Mossberg 500	13.75	6.85	38.50	14.50	13.75	6.05
	Kel-Tec KSG	8.00	2.28	18.50	6.65	5.75	3.28
	Saiga-12	18.50	6.02	25.75	10.00	15.25	4.48
	SRM-1216	18.25	6.70	34.75	14.52	17.00	4.30
90 ft.	Remington 870	9.00	3.05	15.25	5.75	10.50	3.30
	Mossberg 500	17.75	5.55	36.00	18.00	17.50	5.30
	Kel-Tec KSG	13.50	3.70	34.00	12.80	7.00	2.40
	Saiga-12	21.75	6.50	27.75	8.50	7.00	2.40
	SRM-1216	28.25	7.75	44.50	15.00	7.75	2.83

Note: E.S. = Extreme Spread; M.R. = Mean Radius

Table 4. Projectile Drop by Ammunition and Launcher

Report

		DROP		
		Ammunition		
Weapon	Distance	CTS	ALS	Def Tech
Remington 870	30 ft	.75	.00	.75
	40 ft	3.25	1.00	2.25
	50 ft	4.00	2.75	4.25
	60 ft	4.25	3.25	5.75
	70 ft	10.25	1.75	7.50
	80 ft	12.00	6.50	12.50
	90 ft	13.75	11.50	15.75
Mossberg 500	30 ft	1.75	.25	-.75
	40 ft	.25	1.75	.00
	50 ft	.75	.25	1.50
	60 ft	2.50	2.50	2.75
	70 ft	4.00	.50	7.00
	80 ft	9.75	-1.00	9.75
	90 ft	10.25	6.50	9.00
Kel-Tec KSG	30 ft	.75	1.00	1.75
	40 ft	1.00	1.75	3.00
	50 ft	.75	.50	3.25
	60 ft	2.75	1.00	3.50
	70 ft	5.00	3.00	5.00
	80 ft	7.25	7.50	14.00
	90 ft	8.75	6.00	13.75
Saiga-12	30 ft	6.25	6.00	8.25
	40 ft	7.75	9.00	11.00
	50 ft	12.00	11.75	13.00
	60 ft	17.25	16.75	19.00
	70 ft	21.00	20.00	23.25
	80 ft	26.75	23.50	31.75
	90 ft	34.25	25.00	38.50
SRM-1216	30 ft	3.75	4.00	4.50
	40 ft	4.75	4.50	5.75
	50 ft	6.00	5.75	7.50
	60 ft	3.75	1.25	8.00
	70 ft	11.25	9.50	16.75
	80 ft	19.25	14.25	17.50
	90 ft	20.75	22.00	24.50

QUALITATIVE ANALYSIS

There has been an increased trend in the use of qualitative observations to supplement quantitative analysis and a number of unique observations were made in this study. These observations fell into two distinct categories: munitions-based and weapon-based. The munitions-based observations focused primarily on factors that appeared to negatively affect accuracy while weapon-based observations centered on specific mechanical problems or malfunctions.

Beanbag Performance/Malfunctions

Figure 2. Variance in Shape

Beanbags of divergent sizes are shown in Figure 2. Their weights were not statistically different and chronograph results were similar. However, the larger beanbags deviated substantially from the rest of the target distribution. Observers noted that they could actually observe the beanbag curve in flight. It is believed that the larger surface area contributed to projectile instability.

Figure 3. Wadding Malfunction

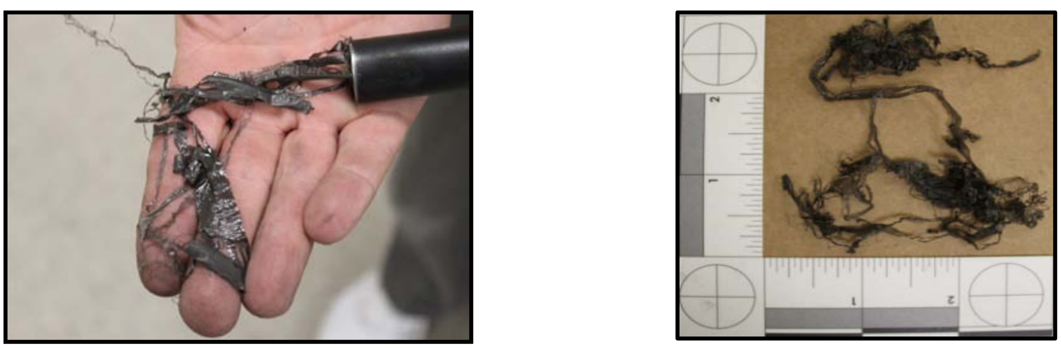
Figure 3 illustrates a recovered projectile where the wadding stayed attached to the beanbag after it was fired. Again, observers noted a dramatic trajectory change as the beanbag travelled downrange. In this case, the wadding acted as a sail or parachute causing the beanbag to spiral in a corkscrew fashion. The distance traveled determined the location in the “spiral” the beanbag would strike the target (i.e., high, low, left, right).

Figure 4. Beanbag Tail Differences

Figure 4 illustrates the differences between different tails that were collected after firing. The lengths were actually very similar but it appeared that many of the tails failed to completely extend. Since these beanbags require the tail to stabilize the trajectory, accuracy is negatively impacted when they lose the ability to function properly.

The impact of residue created by less lethal munitions cannot be overstressed. All three brands of ammunition create similar amounts of this plastic, stringy residue (shown in Figure 5) that continues to build from shot to shot. Semi-automatic shotguns appear more susceptible to this type of build-up and begin malfunctioning after approximately thirty shots. Pump shotguns are more resilient but eventually they too will fail if not properly cleaned after deployments.

Figure 5. Residue Build-Up in Barrel



As shown on the beanbags below in Figure 6, the amount of residue transferred onto the beanbag progressively increases. The more shots that are fired, the dirtier the weapon becomes and there is a visibly clear difference between first shot and the last shot of this series. From a forensic standpoint, it may also be possible to reconstruct the shot order or even differentiate between shooters based upon this transfer onto the beanbag material. Also illustrated below are the differences between the beanbags such as their shape, size and their tail lengths. None of these factors are discernable by inspecting the exterior of the shotgun shell prior to use.

Figure 6. Increasing Residue Transfer onto Beanbags

WEAPON PERFORMANCE AND MALFUCNTIONS

Malfunctions were documented as they occurred for each weapon. A malfunction is classified as: *issues found, when a firearm failed to cycle, when a firearm failed to fire, and any issues that prevent the firearm from working properly*. The control firearms (Remington 870 and Mossberg 500) had no recorded malfunctions throughout testing.

Kel-Tec KSG

This shotgun was added to the study at the last minute due to its recent entrance into the firearms market and its potential as a light-weight, high capacity weapon. It is a first attempt at a shotgun by Kel-Tec and we received an early pre-production model. It utilized multiple picatinny rails which allowed addition of a tactical lights, laser, and scope or sight system. In this case, it was decided to utilize simple iron peep sights similar to those on the other weapons under study. The Kel-Tec KSG performed surprisingly well in both accuracy and overall performance for its purchase price. The weapon's size and bull pup configuration provide considerable firepower in a portable platform that might have application for highly mobile units such as canine teams but additional testing and evaluation is necessary.

However, one mechanical problem initially presented itself. The weapon appeared sensitive to an issue known as "short-stroking "and multiple failures were a result. When cycling a round, if the pump action was not completely and seamlessly performed, the next round of ammunition would fall below the shell lifters. This action causes a *failure-to-feed malfunction* resulting in a shotgun shell to be lodged under the shell lifters and subsequently blocking the breach. Additionally, the misaligned shell can come in contact with the entrance to the magazine tube and release an additional shotgun shell creating a *double-feed malfunction*. In our attempt to clear this malfunction, we found that it was possible to create a *triple-feed malfunction* which took the weapon completely out of service. This is illustrated in the photo below in Figure 7.

Figure 7. Triple Feed Malfunction

When this occurred, it was impossible to correct the jam immediately using standard clearing techniques. It was possible remove the shells by manually rotating them around the lifters but took the weapon completely out of service until it was completed. The pump cycle on the KSG is slightly different than other pump shotguns and requires a minimal amount of additional orientation training. After a five minute training session, no additional malfunctions were observed in the KSG.

Saiga-12

The Saiga-12 is a variant of the Kalashnikov design and a distant relative within the AK-47 family manufactured by Izhmash and imported by the Russian-American Armory Company. This weapon is still in use by the Russian Spetnaz Special Forces group but has become popular as a home defense weapon. During an earlier study of semi-automatic shotguns, the research team became aware of a gunsmith at Cadiz Arms that had developed a modification to the Saiga-12 to allow it to cycle beanbag ammunition. Although we were initially skeptical, the weapon did perform as advertised and cycled beanbag ammunition in a semi-automatic fashion. The weapon had several decided strengths. First, it had a very high rate of fire and a single officer would have the ability to engage a large number of combatants. Second, it had detachable magazines which allowed rapid reloading. Finally, as it was similar to a Kalashnikov, it utilized a simple design and was easy to field strip. Unlike the other weapons in this study, this is an experimental firearm that is still under development and results should be viewed in that light.

The Saiga-12 had several malfunctions present during testing. The initial issue observed was the detachable magazine repeatedly falling off the firearm after a shot was fired. This occurred after the magazine was observed to have been correctly locked into place on the firearm. Unlike AK-47 magazines that are durable and metallic, the Saiga-12 magazines are almost completed comprised of a composite material that tends to wear quickly. At the time of this report, no metal magazines could be located on the U.S. market.

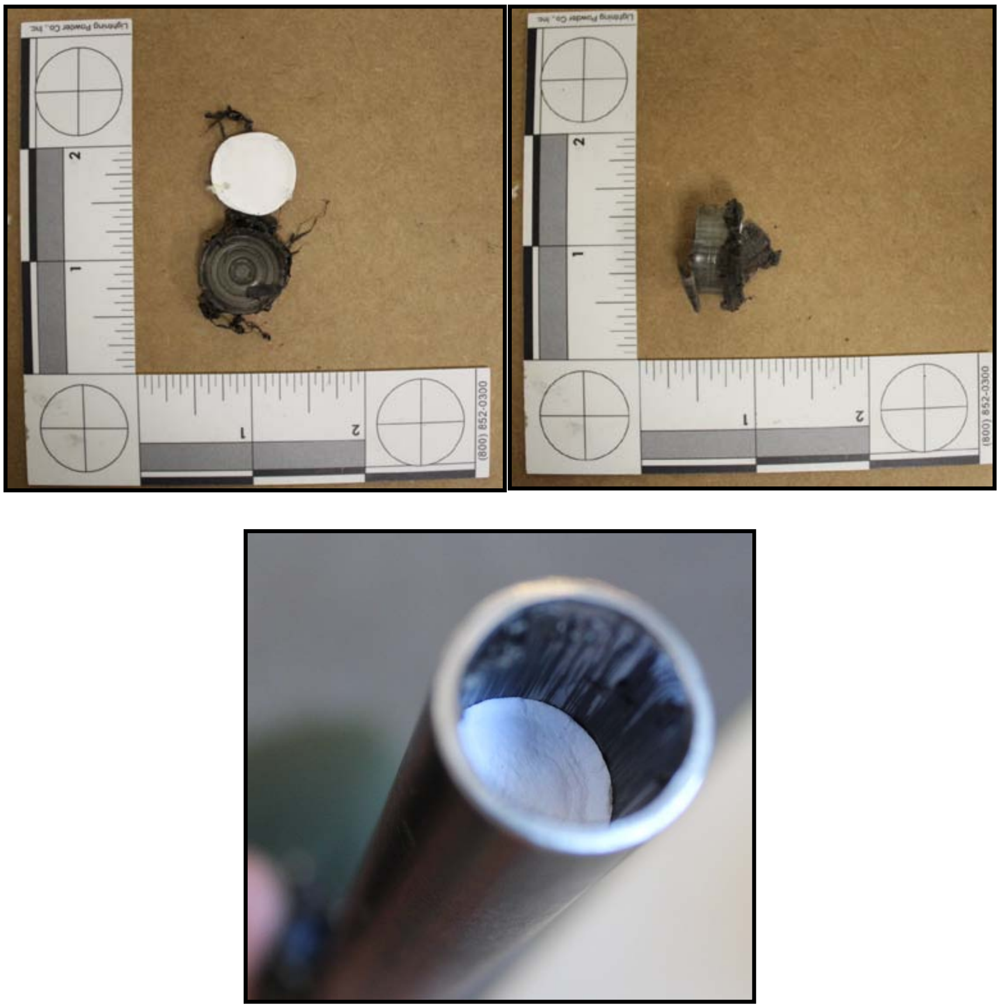
The Saiga-12 also had several instances where the magazine was inserted and the bolt was engaged but failed to fire. Both of these malfunctions were attributed to an individual magazine which was replaced. It also was determined that Saiga-12 magazines that are loaded to full capacity exhibited a number of failure-to-feed or failure-to-fire malfunctions. The five round magazines did not exhibit this anomaly but it was present in the larger magazines. These malfunctions ceased after a reduction of loaded rounds in each magazine.

Another malfunction that was observed was a failure to eject a spent casing. The round would be fired and the shell casing would fail to eject from the breach or the expelled shell would “stovepipe” jam. Traditional clearing techniques were ineffective until a magazine removal was first completed. This malfunction tended to occur as the weapon became “dirty” after repeated test firings.

The most serious malfunction observed was a total blockage of the barrel created by pieces of the wadding that would lodge in the barrel, which are shown in Figure 8. The bottom photo shows the blockage looking down the barrel. This created the risk of a barrel rupture had another round been discharged into the blockage. Fortunately, specific safety measures were taken to reduce this risk and a barrel rupture never occurred.

This required the firearm to be completely stripped and the barrel to be cleared with a cleaning rod and bore snake. This malfunction sporadically occurred with one brand of ammunition (CTS) and occurred with increased frequency in the later stages of testing. The manufacturer of the firearm was notified of the problem and advised the researchers to thoroughly clean the gas system of the firearm, a step not normally taken during maintenance. The gas system was found to be blocked by an enormous amount of residue that beanbag ammunition is known to leave behind. The gas system then had to be disassembled, cleaned and allowed to dry. Initially, this appeared to resolve the malfunction. However, this malfunction continued to occur with CTS ammunition whenever the weapon became fouled with residue.

Figure 8. Wadding Lodged in Barrel



SRM-1216

SRM-1216 is a semi-automatic shotgun that utilizes a four (4) tube, sixteen (16) shot cylinder detachable magazine. This weapon requires a special bolt to cycle less lethal beanbag rounds which is not standard with the firearm. As with the Saiga-12, it also has a high rate of fire but similarly suffers from magazine malfunctions. The magazine is spring loaded and has a shell retainer at the end of each tube that is meant to hold the ammunition in place. If the shell retainer was touched at all during loading, the rounds would cascade out of the magazine (as shown in figure 9). The research team contacted the manufacturer as this happened frequently during magazine changes. The manufacturer informed that prototype magazines had been sent with the gun and that new magazines would fix this problem. This problem ceased when the prototype magazines were removed from service.

Figure 9. Magazine Failures

When the magazine was able to be properly inserted into the weapon, a fail to feed malfunction then became an issue. The magazine is required to be manually rotated after each four shot magazine tube has been expended and the bolt automatically locks in the rearward position. When the magazine cylinder was rotated to the next tube, the subsequent round would jam and end the feed sequence. While this did not occur every time, it did occur with great frequency. As with the Saiga-12, the SRM-1216 also had failed to fire malfunctions. The round would load into the chamber but upon pulling the trigger the weapon would fail to fire. The magazine would then have to be removed and the round ejected manually and the load sequence re-started. It was later determined that both fail-to-feed and fail-to-fire malfunctions were linked to the magazine. While the Saiga-12 magazine malfunctioned when it was loaded to full capacity, the SRM-1216 malfunctioned when the magazine was not fully loaded. All malfunctions disappeared after the SRM magazine was loaded with 14 rounds, although how this affects the performance of the weapon is still unclear.

IMPLICATIONS

The data and observations tend to support the findings of prior research in the area of less lethal beanbags (see Wayne State University, 2011; Bozeman, 2005). Extreme variances in the ammunition drastically impacted the accuracy and performance of the projectiles and quality control varied substantially between the competing ammunition manufacturers. A cumulative effect on performance was observed when the individual attributes of each launcher was added to the analysis as each launcher produced a distinct trajectory curve for each brand of ammunition. From the qualitative and quantitative analysis, it was clear that certain brands of ammunition performed better in a specific launcher while others performed erratically or poorly.

However, all variables that were held constant in this study may significantly impact actual field deployments and produce unacceptable results, particularly at greater distances. Consequently, it becomes difficult, if not impossible, for the user to correct their point of aim and compensate for extended distances without some degree of testing and evaluation on the part of the law enforcement agencies or substantially more quality control on the part of the ammunition manufacturers.

While the emergence of semi-automatic shotguns as less lethal launchers is a considerable leap in law enforcement technology, its value its substantially reduced by the negative impact of fouling residue created by the ammunition. It was also observed that both semi-auto shotguns fired their projectiles at a lower velocity which affected accuracy. Cleaner ammunition designed specifically for these semi-automatic launchers may be required for optimal performance.

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APPENDIX

Remington 870

Product Specifications

Manufacturer:	Remington
Magazine Type:	Singular tube
Magazine Capacity:	Four
Cycling Type:	Pump Action
Barrel Length:	18”
Sights:	Bead sight
Cost:	$349.99
Website:	**http://www.remington.com**

Mossberg 500

Product Specifications	
Manufacturer:	Mossberg
Magazine Type:	Singular tube
Round Capacity:	Five
Cycling Type:	Pump Action
Barrel Length:	18.5”
Sights:	Bead sight
Cost:	$321.99
Website:	http://www.mossberg.com

Kel-Tec KSG

Product Specifications

Manufacturer:	Kel-Tec
Magazine Type:	Twin
Round Capacity:	Fourteen
Cycling Type:	Pump Action
Barrel Length:	18.5”
Sights:	Peep sights
Cost:	$799
Website:	http://www.keltecweapons.com/

Saiga-12

Product Specifications	
Manufacturer:	Izhmash
Modified by:	Cadiz Gun Works
Magazine Type:	Detachable
Round Capacity:	Five or ten
Cycling Type:	Semi-automatic
Barrel Length:	19”
Sights:	Bead sight
Cost:	$1200
Website:	**http://www.cadizgunworks.com/**

SRM-1216

Product Specifications	
Manufacturer:	SRM Arms
Magazine Type:	Detachable
Round Capacity:	Sixteen
Cycling Type:	Semi-automatic
Barrel Length:	18”
Sights:	Peep sights
Cost:	$2399
Website:	**http://srmarms.com/store/pc/home.asp**