PepperBall® SA-4 Launcher™ Accuracy Study

CHARLIE MESLOH, PhD
Associate Professor, Florida Gulf Coast University

LINDSEY MEDLEY, B.S.
Graduate Assistant, Florida Gulf Coast University

JOANN WERBALIS, B.S.
Graduate Assistant, Florida Gulf Coast University

ROSS WOLF, EdD
Technology Advisor/Senior Research Associate, WERI
and Associate Professor, University of Central Florida

The project was supported by Award No. 2009-DI-BX-K008, by the National Institute of Justice, Office of Justice Programs, United States Department of Justice. The opinions, finding, and conclusions or recommendations expressed in this publication are those of the author and do not necessarily reflect the views of the Department of Justice.

Table of Contents

Table of Figures

Table of Tables

Disclaimer

While every effort has been made to ensure the accuracy of the information contained in this report, any errors of commission or omission are solely the responsibility of the research team. The research team shall not be liable for any damages or injury caused by errors, inaccuracies, omissions, or other defects in the content or any of the products tested, or any of the products referred. The researchers shall not be liable for any third-party claims or losses of any nature, including but not limited to, any claims or losses relating to any product referred to at any time in the content of this report. The researchers do not intend for references to corporations, products, or entities to be endorsements of such and the researchers are not affiliated with, sponsored by, or endorsed by any consumer product in this report.

Abstract

The purpose of this study was to examine the overall functioning of the PepperBall® SA-4 Launcher™. This less lethal weapon is a chemical irritant handheld-launcher pistol, which fires a special *ImpactPlus®* projectile. The SA-4 Launcher™ is designed for crowd control and suspect compliance, with the ability to fire four (4) shots of ammunition. The manufacturer stated range for this weapon is 25-30 feet, with approximately 20 foot pounds per projectile and a muzzle velocity of 320 feet per second (fps).

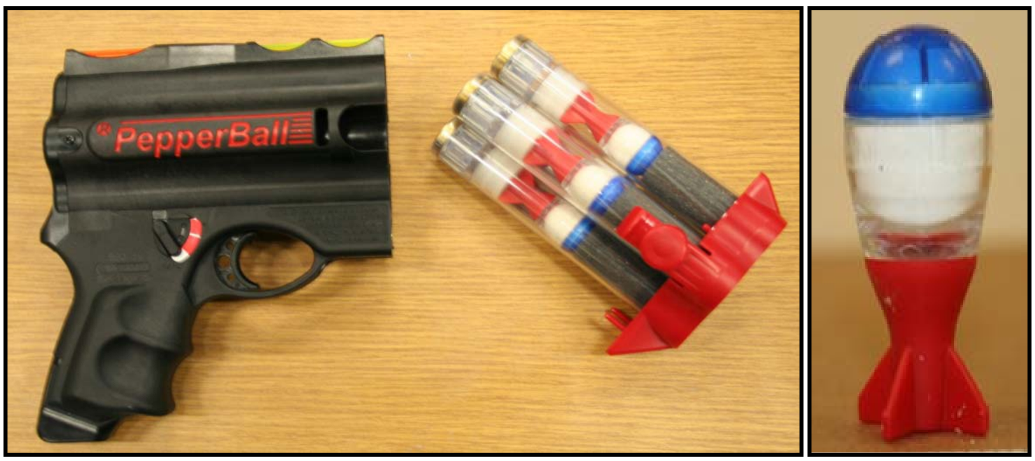
This study tested the overall functioning and reliability of the weapon. The study found that the average muzzle velocity was very close to manufacturer estimations at 327.74 fps. This study produced a linear regression model with the goal to provide an operator the ability to compensate for ballistic drop to attain the desired point of impact. However, it was determined that the projectile tended to "float" or rise rather than drop in a consistent manner.

Introduction

The PepperBall® SA-4 launcher™ is a battery powered, semi-automatic, rapid firing pistol. It houses four 12-gauge projectiles and is classified by the United States Department of Alcohol, Tobacco, Firearms and Explosives (ATFE) as a firearm because a shotgun primer is used to fire the projectiles. The launcher has four different chambers to load projectiles: top, bottom, left, and right. The weapon is compact and can be easily holstered and the manufacturer estimates that it strikes the target with approximately 20 foot-pounds of kinetic force per projectile. According to the PepperBall® Technologies, Inc. Specification Sheet, the SA-4 Launcher™ is accurate up to 25-30 feet in range depending on one's proficiency and has a velocity of 320 feet per second. The launcher is equipped with a built-in high visibility laser, and has a 3 position switch that engages the gun from *safe*, *stealth-on*, and *laser-on*, to aid in establishing a point of aim (POA). The laser is pre-set prior at the factory, as are the high visibility sights, which according to PepperBall® "operators should conduct testing at their facilities to verify point of aim/point of impact." The total weight of the weapon is less than one pound. The launcher can be used in use of force situations to gain suspect compliance, in crowd control, barricade and standoff situations, as well as self-defense.

The SA-4 Launcher™ is much different than other PepperBall® systems as it uses an *ImpactPlus*® projectile instead of a standard PepperBall® projectile. *ImpactPlus*® projectiles have a variety of applications in law enforcement and corrections (see *Figure 1*). These rounds can be filled with many different chemical agent formulations, including inert scented powder for training purposes and PAVA, which is capsaicin II powder or extremely hot pepper powder (SA-4 Field Operator Training Manual, 2007).

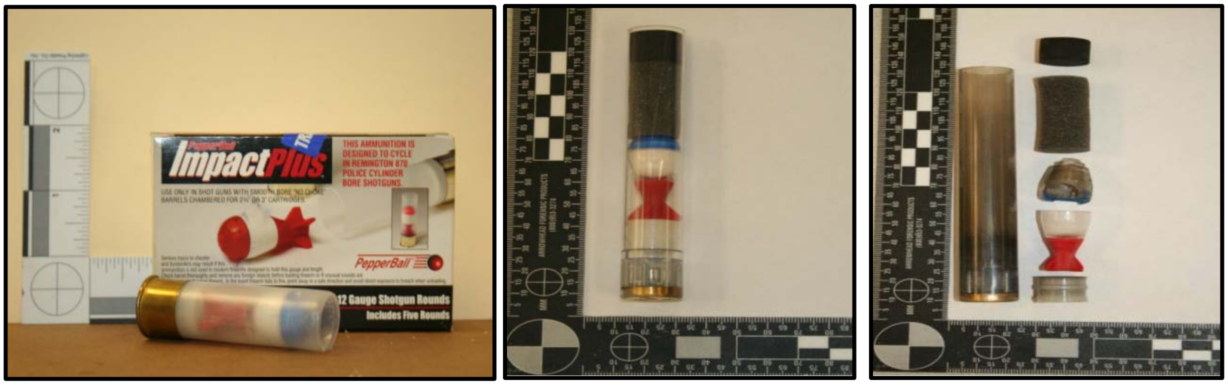
Figure 1. SA-4 Launcher and Projectiles



The SA-4 *ImpactPlus®* projectile contains twice as much PAVA as a standard PepperBall® and the PAVA strength is reported to be ten (10) times greater. The gun holds up to four projectiles per magazine. The projectiles are housed in long plastic tubes with the primer built into the end, and each is a fin-stabilized, powder-filled, frangible plastic and a “rocket-like” projectile. Foam is enclosed in the tube to help keep the projectiles from sliding out the end. According to Munson (2008), the foam stopper may cause the projectiles accuracy to be affected. *Figure 2* illustrates the 12 Gauge *ImpactPlus®* projectile (left photo) followed by the “rocket-like” projectile used in the SA-

4 Launcher™ (center photo). The picture to the far right illustrates the different components of an individual SA-4 shell once it has been fired.

Figure 2. SA-4 Munitions Components



When reviewing less than lethal munitions, it is important to discuss the potential for injury. Even law enforcement munitions that most closely resemble civilian paintballs have resulted in injuries. These include injuries from the impact of the munitions onto the target subject, or injuries resulting from the delivery of the payload. At events where crowd control is necessary, it is unlikely that individuals that are struck by PepperBalls® munitions will be wearing eye protection, and they therefore risk severe injury. Ocular trauma is the predominant injury resulting from the use of paintball guns (Feist & White, 2002). The munitions used for the SA-4 may result in similar injuries to those found from paintball-type delivery devices. The target area for impact is the torso, and the head, neck and groin areas should be avoided (SA-4, 2007). According to Bozeman & Winslow (2005), kinetic impact munitions are fairly inaccurate due to the poor aerodynamics of these projectiles' large surface area. The force derived from these munitions depends greatly on the distance they must travel. The distance also greatly affects the weapons accuracy.

Methodology

A research design was created to measure the performance of the PepperBall® SA-4 Launcher™. The primary goal was to identify the accuracy, reliability, and range and determine if any malfunctions presented themselves during testing. Inert munitions (carrying payloads of inert powder) were utilized for the testing of the weapon. There were six (6) different shooting intervals utilized for this testing. The first shooting interval was at a distance of ten (10) feet, then at five-foot increments with the final shooting distance at 35 feet. At each distance, ten (10) shots were fired at the point of aim (POA) on the target, for a total of 60 shots. One shooter was utilized to limit the effect of skill on shooting. In order to reduce human error during the testing, the SA-4 Launcher™ pre-set laser (factory setting) was used to determine the POA, and a gun vice was used to support the weapon. Photographs, videos and measurements of the targets were taken at each distance. The POA was consistent on each target at each distance, and was demarcated by an orange sticker on the target.

Accuracy was measured as the difference between the point of aim (POA) and the point of impact (POI) in order to assess the elevation, drift and maximum spread of the projectiles. The center of the shot grouping was identified by using the average group radius method. The drift of the projectile was found by taking the shot that was furthest to the left of the POA and getting the average of all the shots from this distance. The elevation was found by locating the lowest shot and obtaining the average of all the shots from this distance. 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 for each of the six firing positions. 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.

A second method was then utilized to further quantify accuracy. Maximum spread (also known as extreme spread) was measured to determine distance between the two furthest shots of the shot pattern or grouping. This is a less accurate method of measuring the group size and does not provide a valid measure of central tendency for statistical analysis. The weakness of this system is that it relies solely upon the two most extreme observations and discounts all of the remaining data points. However, it is one of the most commonly used methods of calculating the performance of a weapon or ammunition due to the ease of data collection.

A chronograph was set up to test the stated velocity of 320 feet per second. Twenty (20) shots were fired to determine the average projectile velocity.

Figure 3. Test Firing

According to the PepperBall SA-4 Launcher Field Operator Training Manual (2007) the *ImpactPlus®* projectiles weigh approximately 5.7 grams, while the inert scented powder weighs approximately 3 grams. The weights of the individual projectile components were measured after disassembling one of the projectiles. The rocket-like projectile was weighed in its casing at 4.83 grams, and then the inert payload was measured at 3.22 grams.

Findings

The results were placed into a statistical software package (SPSS 11) for quantitative analysis. SPSS 11 made it possible to evaluate the data using advanced statistical methods beyond that of mere comparison of averages. In terms of individual relationship between the independent variable (distance) and the dependent variables (drift, elevation, maximum spread), drift ($t=-2.84$, $p<.05$), elevation ($t=3.56$, $p<.05$), and maximum spread ($t=4.62$, $p< .01$), the overall goal of this project was to create a predictive model that would allow a SA-4 user to determine where the projectile would strike given a known distance.

Drift Relationship

A linear regression was conducted to measure the strength of the relationship between the distance from the target and the drift of the projectile from the point of aim (*Table 1*). The greater the distance the projectile is from the target area, the more likely the projectile is to drift to the left from the point of aim. The unstandardized coefficients of the regression model indicate that for every five (5) feet of distance, the drift would be approximately one (1) inch to the left of the point of aim. At the closest distance (ten feet), the drift is at 2.5 inches to the left of the point of aim and the weapon's laser system is set at the factory and not correctable by the user.

Table 1. Linear Regression of Drift

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.817[a]	.668	.585	1.52655

a. Predictors: (Constant), Distance to Target

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18.772	1	18.772	8.056	.047[a]
	Residual	9.321	4	2.330		
	Total	28.094	5			

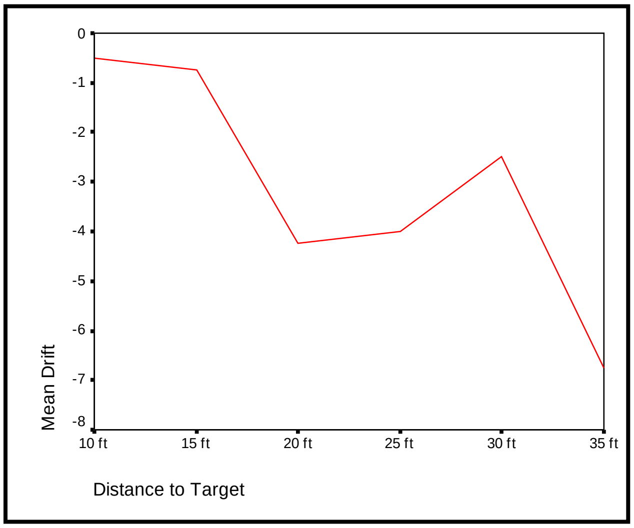
a. Predictors: (Constant), Distance to Target

b. Dependent Variable: Drift

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.500	1.421		.352	.743
	Distance to Target	-1.036	.365	-.817	-2.838	.047

a. Dependent Variable: Drift



Elevation Relationship

A linear regression was conducted to measure the strength of the relationship between the distance from the target and the elevation of the projectile from the point of aim (Table 2). Projectiles normally drop in a predictable fashion as they travel down range. However, in this study the projectiles drift upward or "float" which was also documented in a previous PepperBall® study (see Mesloh and Thompson, 2004). The unstandardized coefficients of the regression model indicate that for every five (5) feet of distance, the projectile was expected to rise .42 inches.

Table 2. Linear Regression of Elevation

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.871[a]	.759	.699	.49642

a. Predictors: (Constant), Distance to Target

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.108	1	3.108	12.612	.024[a]
	Residual	.986	4	.246		
	Total	4.094	5			

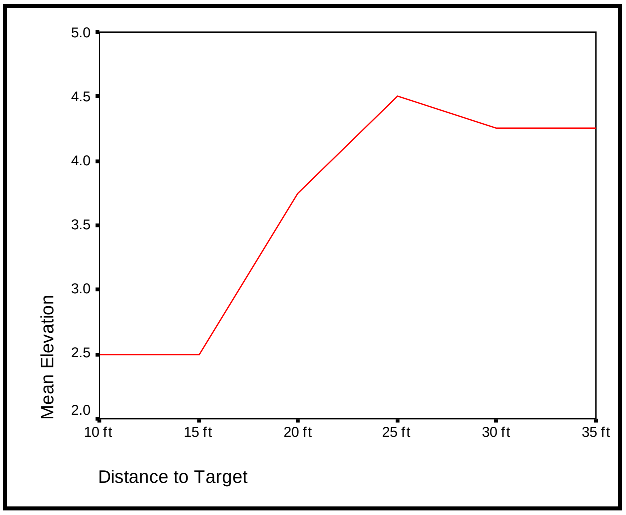
a. Predictors: (Constant), Distance to Target

b. Dependent Variable: Elevation

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.150	.462		4.652	.010
	Distance to Target	.421	.119	.871	3.551	.024

a. Dependent Variable: Elevation



Maximum Spread Relationship

A linear regression was conducted to measure the strength of the relationship between distance and maximum spread (the two furthest distances or outlying shots of point of impact). The unstandardized coefficients of the regression model indicate that 3.65 inches of spread was expected for every five (5) feet of distance. Beyond twenty feet, the spread of the projectiles is substantial.

Table 3. Linear Regression of Maximum Spread

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.920[a]	.846	.807	3.26088

a. Predictors: (Constant), Distance to Target

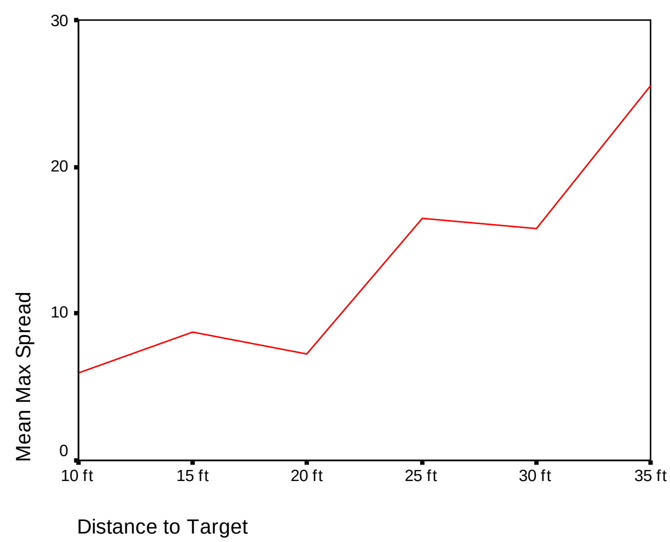
ANOVA[b]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	233.144	1	233.144	21.926	.009[a]
	Residual	42.533	4	10.633		
	Total	275.677	5			

a. Predictors: (Constant), Distance to Target

b. Dependent Variable: Max Spread

Coefficients[a]						
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	.517	3.036		.170	.873
	Distance to Target	3.650	.779	.920	4.682	.009

a. Dependent Variable: Max Spread



Velocity Relationship

The manufacturer listed the velocity for the munitions as 320 feet per second (fps); this current study found the majority of test shots fell within a 28 fps difference from manufacturer specifications. A chronograph was set up to test the said velocity of

320 feet per second. There were 20 shots fired to determine the average velocity. *Table 4* shows the average velocity of the 20 shots was 327.74fps. The minimum velocity was 274.4 fps, with the maximum at 369.7 fps.

Table 4. Projectile Velocity Mean Data

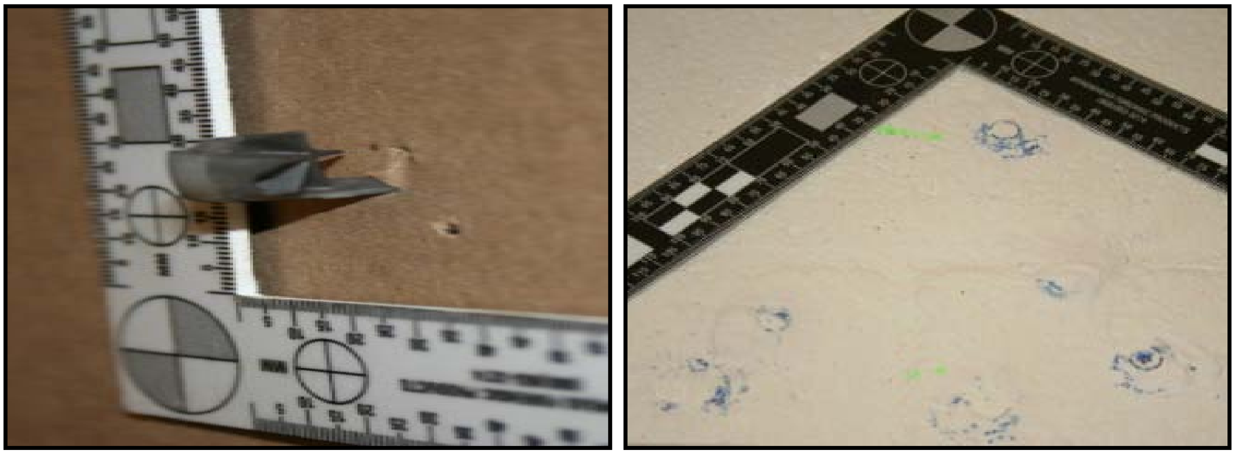
Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Projectile Velocity	20	274.40	369.70	327.7350	28.02396

Malfunctions

Debris was observed leaving the weapon in several cases as the munitions were fired*.* *Figure 5* illustrates part of the wadding that was discharged and found stuck in the target (left photo). Also illustrated, (right photo) is an example of how the projectile impacted the wall with full force and left pieces of the plastic stuck in the wall. According to the SA-4 Field Operator Training Manual (2007), “head shots could result in unintentional, severe, and permanent injury or death.” Suspects are likely to lean forward after being impacted by the projectile, so officers should adjust their aim if more shots are required.

Figure 4. Malfunctions



Conclusion

The purpose of this preliminary study was to evaluate the SA-4 PepperBall® System with regards to its overall functionality, accuracy, reliability, velocity and possible malfunctions. The greater the distance the projectile is from the target area, the more likely the projectile is to drift 1.5 inches away from the point of aim. At the closest distance, the drift is at 2.5 inches to the left of the point of aim. The weapon's overall accuracy was consistent within the manufacturer's stated range of 25 feet. The average velocity was 327.74fps, which was reasonably close to the manufacturer stated velocity of 320fps. However, it appears that the projectiles "float" rather than drop, which may have a propensity to cause ocular or head injuries in actual field use. The weapon performed within the parameters and specifications of its user manual. Further testing is recommended beyond this initial pilot study.

References

Bozeman, W. P., & Winslow, J. E. (2005). Medical Aspects of Less Lethal Weapons. *The Internet Journal of Rescue and Disaster Medicine , 5* (1).

Feist, R. M., & White, M. F. (2002). Ocular Truma from Paintball-Pellet War Games. *Southern medical Journal , 95* (2), 218-222.

Mesloh, C. T., & Thompson, L. F. (2004). Evaluation of the FN303 Less Lethal Projectile. *Journal of Testing and Evaluation , 34* (6), 574-576.

Munson, D. (2008). PepperBall Technologies SA-4 Launcher. *Tactical Response* .

PepperBall Technologies, Inc. Field Operator Training Manual (Revised 2007)

SA-4 Launcher data and specifications as provided by PepperBall Technologies, Inc.

Appendix

Figure 1. Distance at 10 Feet

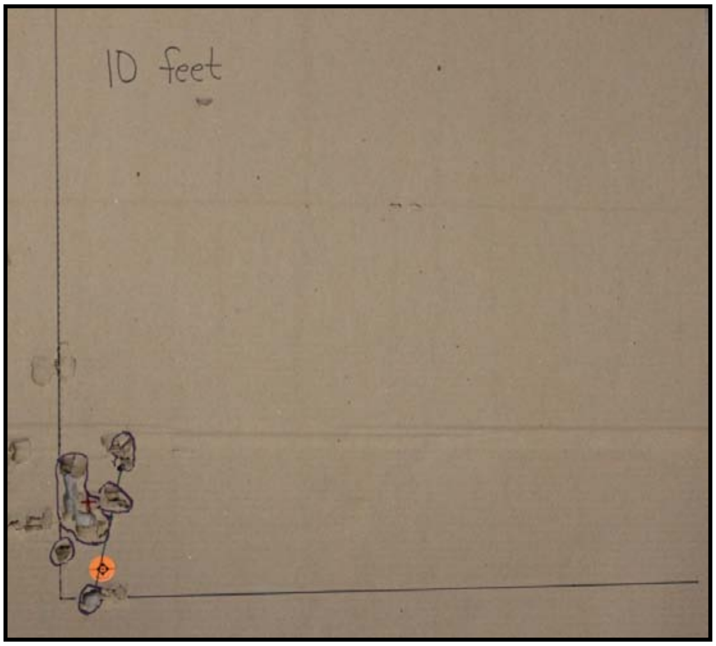


Figure 2. Distance at 15 Feet

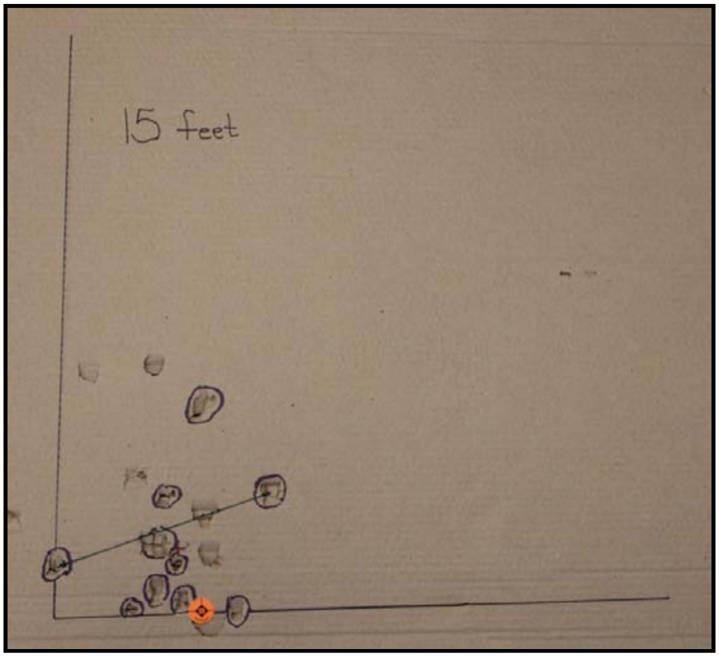


Figure 3. Distance at 20 Feet

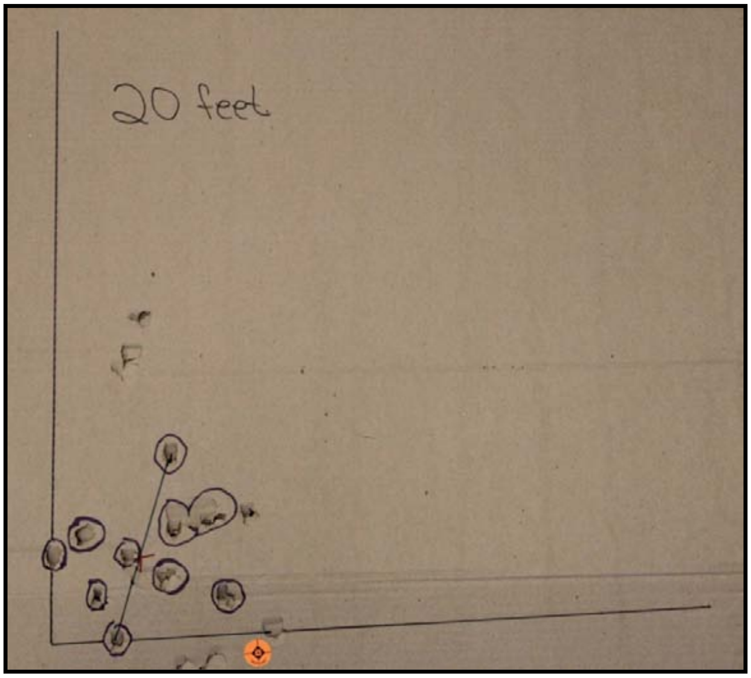


Figure 4. Distance at 25 Feet

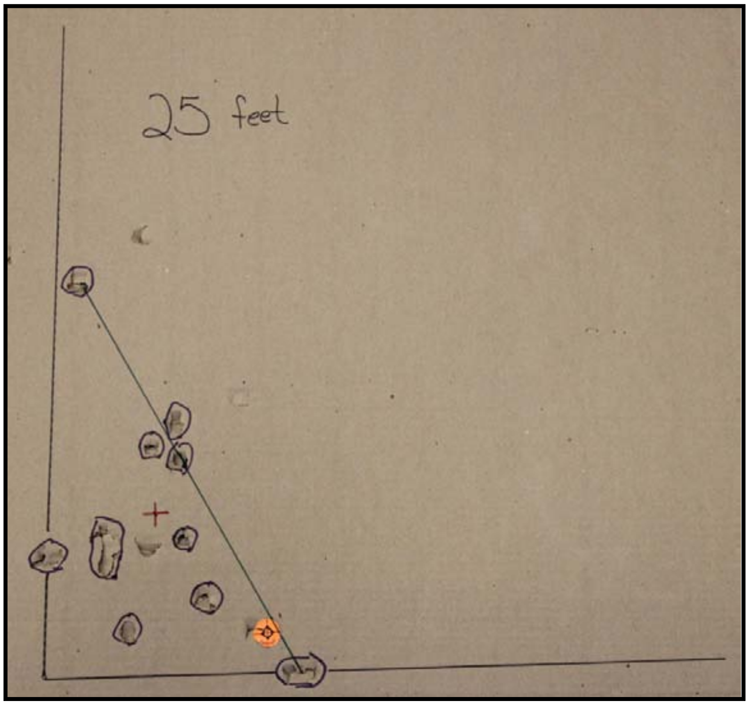


Figure 5. Distance at 30 Feet

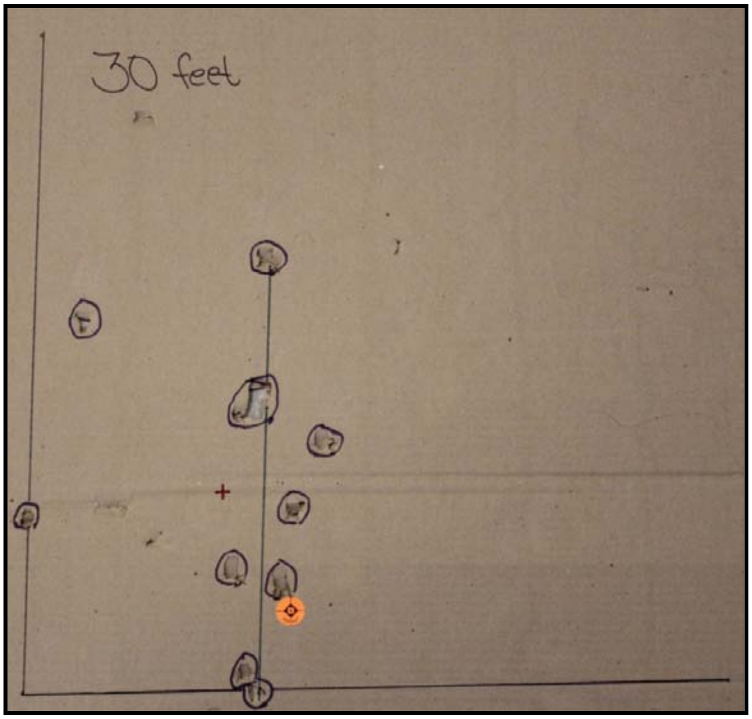


Figure 5. Distance at 35 Feet