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ANALYSIS OF A BEAN-BAG-TYPE PROJECTILE AS A LESS LETHAL WEAPON

(Draft Report)

by
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MAY 1974

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57,9

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This project was supported by Interagency Agreement No. LEAA-J-IAA-014-2 between the Law Enforcement Assistance Administration and the US Army Land Warfare Laboratory and awarded under the Omnibus Crime Control and Safe Streets Act of 1968, as amended. Points of view or opinions stated in this document are those of the authors and do not necessarily represent the official position or policies of the US Department of Justice.

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ACKNOWLEDGEMENTS

This document was prepared by the Research Analysis Office of the US Army Land Warfare Laboratory. Technical research was performed by the authors of the report.

ABSTRACT

The primary objective of this report is the presentation of an effectiveness analysis of a blunt-trauma-producing "nonlethal" projectile, representative of several such items available on the market today, through the application of a previously-established methodology for the evaluation of less lethal weapons. The item chosen for analysis is the Stun-Bag, an MB Associates proprietary bean-bag-type projectile which uses kinetic energy to produce desired effects. It should be noted, however, that the Stun-Bag also produces undesirable effects in the less lethal weapons role. It is emphasized that the Stun-Bag is not investigated for itself, per se, but rather as a representative of a class of projectiles/weapons.

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FOREWORD

The work described in this report was performed under Task Plan II of the LEAA/LWL Interagency Agreement No. LEAA-J-IAA-014-2. Mr. Lester Shubin and Mr. Marc A. Nerenstone were the LEAA Program Monitors for this task. Mr. Donald O. Egner was the USALWL Project Officer, and the project is identified as LWL Task No. 20-Y-72, Subtask II.

Two of the justifications for using the Stun-Bag as the subject of this analysis are:

o It is representative of a class of nonfrangible, blunt-trauma-producing, kinetic-energy-type projectiles.

o It has achieved some popularity as a less lethal (so-called "nonlethal") weapon and was readily available, both from MB Associates and through the commercial market.

The work described in this report is pioneer in nature and the results are subject to change as more knowledge is obtained in the area of study. Comments, data and other information which could improve the analysis described herein are welcome and should be forwarded to the Program Monitor, Less Lethal Weapons Evaluations Program, National Institute of Law Enforcement and Criminal Justice, Law Enforcement Assistance Administration, 633 Indiana Avenue, NW, Washington, DC 20530.

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ACKNOWLEDGMENTS

The authors wish to acknowledge all technical contributions, timely guidance, counsel, data and supporting services which were rendered individually or collectively by members of the LWL Evaluation Panel.

Appreciation is expressed to Mr. John Sarvis, Munitions Branch, LWL, for his participation in the man/weapon system performance tests. Dr. Paul Grant, Milcom Systems Corporation, is credited with initial analysis of the data.

Particular appreciation is expressed to Mr. Joseph W. McNiell, Chief, Research Analysis Office, LWL, for his tireless efforts on behalf of all phases of this report.

SUMMARY

The problem treated in this report is an analysis of the Stun-Bag* as a blunt-trauma-producing, less lethal weapon. The evaluation included analysis of test data, graphical display of key data elements, and resulting observations.

An understanding of the analysis of Stun-Bag effectiveness as presented in this report depends on two factors. One is that law enforcement objectives change as the law enforcement situation, or scenario, changes. The other is that there are (from the law enforcement view) possibilities of both desirable and undesirable effects when a Stun-Bag strikes an individual.

Desirable effects of a projectile or weapon are ones which reflect law enforcement goals and objectives in a particular scenario. Undesirable effects are ones which involve extensive or long-lasting injury to an individual. The "scales" used to measure undesirable effects refer to damage levels of injury to an individual struck by a projectile, so these effects are independent of law enforcement goals.

The approach in this task consisted of a testing program and utilization of an evaluation methodology previously developed by USALWL and reported in "A Multidisciplinary Technique for the Evaluation of Less Lethal Weapons (Volume 1)." The testing program was divided into two segments, one to study the ammunition/projectile performance characteristics and the second to study the damage resulting from Stun-Bag impacts against test animals.

The first segment of the testing program, ammunition/projectile performance characteristics, was conducted at H. P. White Laboratory to study such items as accuracy, flight orientation, impact position, and variance in weights and velocities.

The second segment of the testing program was the medical evaluation of the results of animal tests. This procedure called for a panel of medical

experts to extrapolate the physiological damage produced on a test animal by a Stun-Bag impact to estimate that which would be expected on an "average nude male body." Head damage was estimated from baboon test shots, and body damage was estimated from swine test shots.

Application of the LWL evaluation methodology involved selection of operational scenarios and ammunition. Two scenarios, the Suspect Fleeing on Foot and the Dispersal of a Crowd, were chosen**. Three different rounds of Stun-Bag ammunition were chosen for study to provide a fairly wide distribution of range and kinetic-energy delivery options.

Determination was made of kinetic energy as a function of range for the rounds chosen. These kinetic-energy figures were based on theoretical cal-

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*A shot-filled, pancake-shaped fabric bag manufactured by MB Associates.
**Time and funding limitations prevented consideration of the two remaining law enforcement scenarios (the Barricade and Hostage Situation and the One-on-One Situation).

culations of Stun-Bag trajectories with typical values assumed for Stun-Bag weights and initial velocities.

Estimates of probabilities of desirable and undesirable effects in man were made directly from the results of the animal test shots.

In addition, hit probability estimations were made following a suggestion in Appendix F of the aforementioned LWL Volume I report. [The data required for the Incapacitation Probability Program (IPP) used in the LWL methodology were not available for this study.]

One important result of the testing is an indication of the general time frame in which a Stun-Bag impact can be expected to do its job. Most law enforcement goals call for relatively quick functional disability of a subject to enable his apprehension, or to motivate dispersal of a crowd, after which the functional disability subsides and the subject(s) sustains, at most, minor injuries. Medical evaluations from the animal tests indicated that Stun-Bag impacts tend to cause internal organ damages without providing immediate, functional disability or "stopping power." A typical comparative time/functional disability relationship as a result of a Stun-Bag impact may be observed in Figure 1.

In addition to providing onset time, the analysis resulted in evaluations of the probabilities of desirable and undesirable effects for both the scenario of the Suspect Fleeing on Foot and the scenario of the Dispersal of a Crowd. These evaluations are displayed in Damage Profile Graphs like the ones in Figure 2. The diagonal line is inserted simply as a guide, since a point above the line represents a shot with desirable effects more probable than undesirable effects. The line is not an absolute demarcation of "good" and "bad" weapon performance, but allows some general conclusions.

Test shot data, when applied to the Fleeing Suspect Scenario, indicate a considerably higher probability of undesirable effects than of desirable effects [Note area of test results in the lower right-hand corner of Figure 2(a)]. In terms of weapon performance, this area is the least attractive region of the graph. Here the damage inflicted by the Stun-Bag is destructive without doing the job for which the Stun-Bag was designed. When applying the test data to the Crowd Dispersal Scenario, Figure 2(b), the desirable effects and the undesirable effects expected are "in the same ballpark." The visibility of Stun-Bag impacts to individuals who are not struck undoubtedly contributes to better desirable effects performance.

Results using the evaluation methodology which combine damage estimates, kinetic energy of impacts, and hit probabilities are illustrated by means of Summary Graphs like the ones in Figure 3. Here the figures on the dashed curves represent range in feet from the point-of-fire to the targeted subject. The curve expresses how the overall effect of Stun-Bags and the relationship of desirable and undesirable effects vary with range.

As mentioned previously, the medical evaluations led to some important positive indications. Stun-Bag impacts, for the most part, lack "stopping

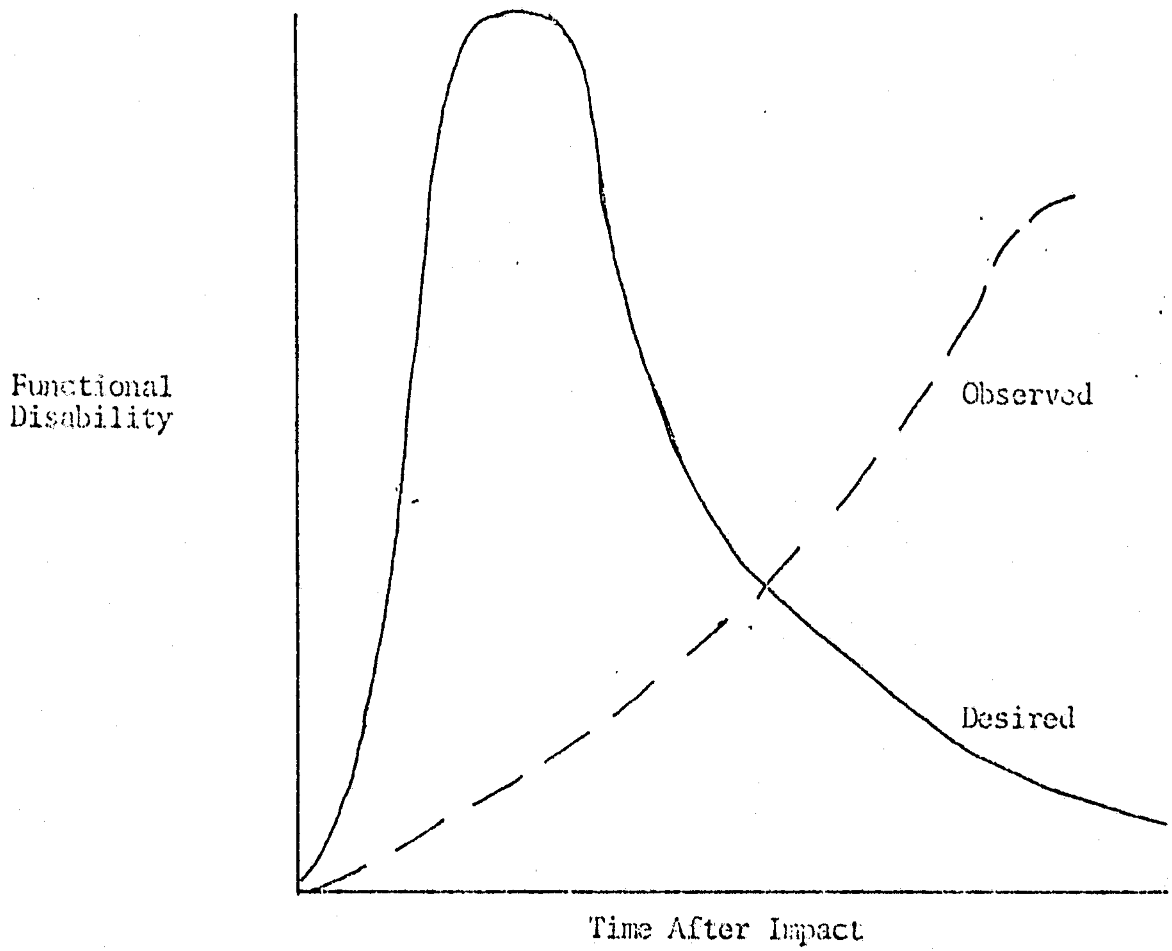


FIGURE 1. Functional Disability of Human vs
Time After Impact by a Stun-Bag

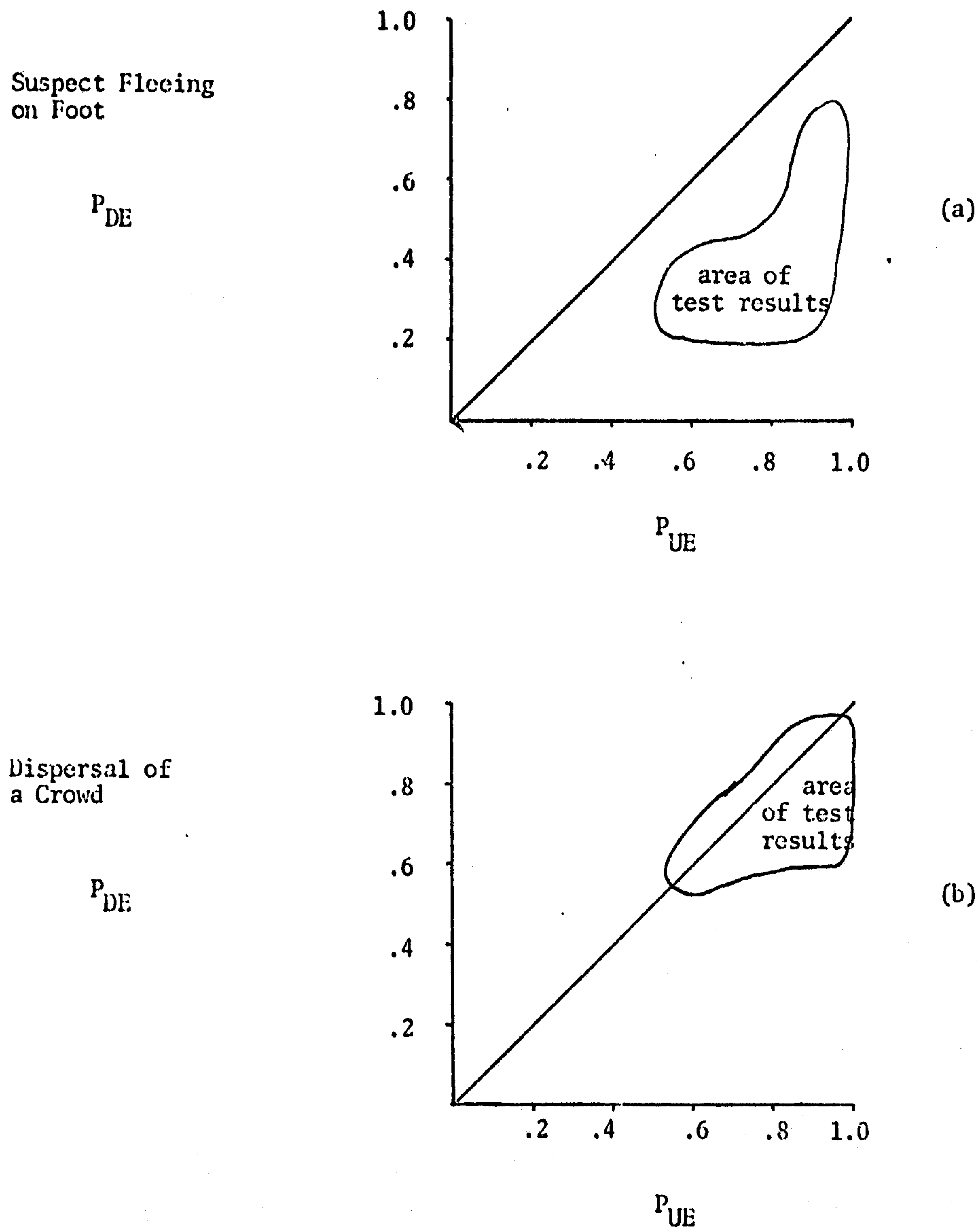
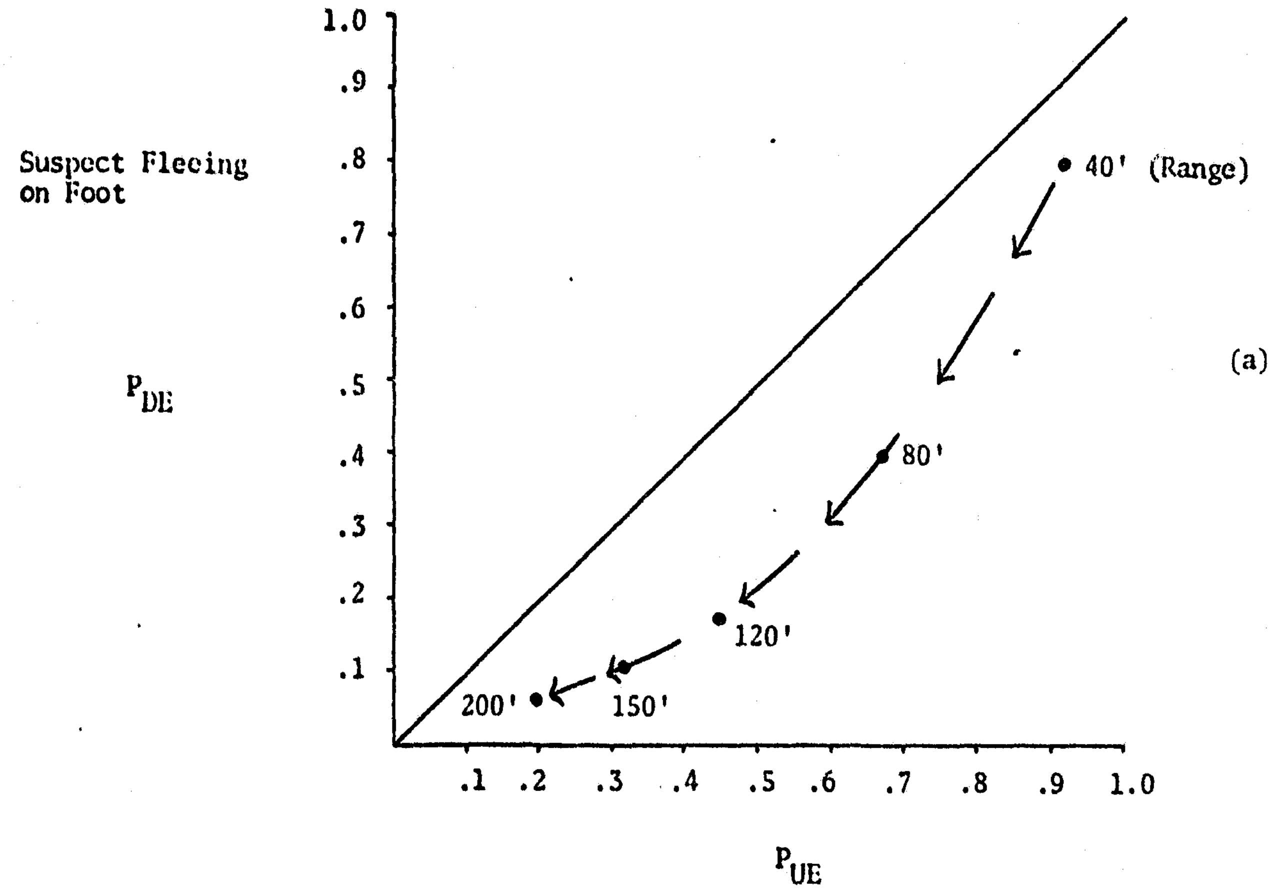
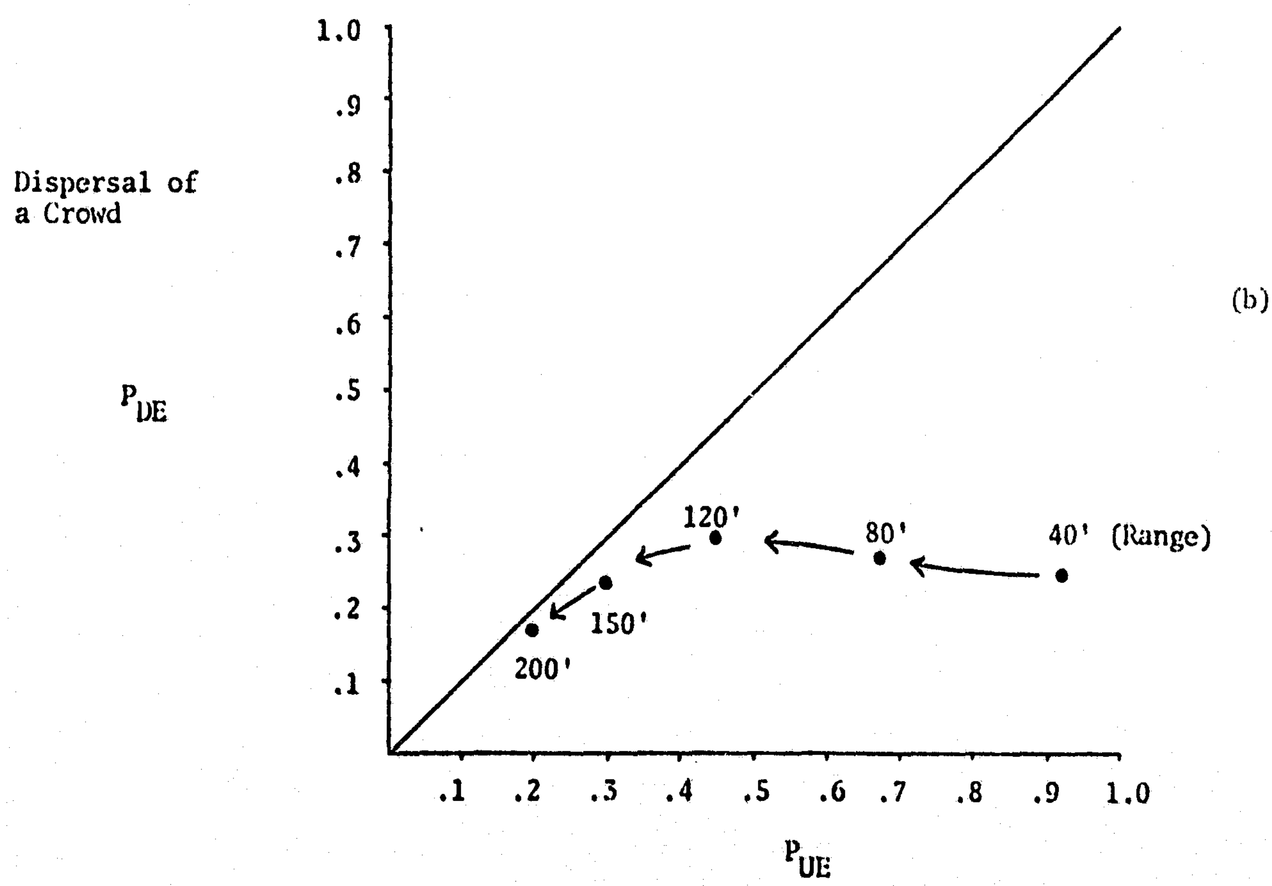


FIGURE 2. Probability of Desirable Effect (P_{DE}) vs Probability of Undesirable Effect (P_{UE}) for the Stun-Bag in Two Basic Law Enforcement Situations

FIGURE 3. Summary Graph (P_{DE} vs P_{UE} as a Function of Range)





power," especially for shots to the body. The reason for this is the relatively lengthy onset time of functional disability. Stun-Bag impacts seem to produce a "liver phenomenon," i.e., unexpected damage to the liver even from low-energy shots impacting body areas remote from the liver. Also, even with the assumption of nudity, there is a serious lack of correlation between skin damage and the extent and location of internal damage.

There are several conclusions to be drawn from the testing and evaluation results. Medical results indicate two areas which require serious attention. The first is occurrence of internal organ damage as a result of impacts by blunt projectiles. This relates to the "liver phenomenon" discovered by this testing program and perhaps is due to a type of pressure wave formation. The second area requiring attention is diagnosis and treatment of blunt impact injuries--particulars of this problem include dissemination of information to doctors on the nature of likely injuries.

As regards the Stun-Bag ammunition/projectile and the Stun-Gun, the Damage Profile Graphs (see Figures 5 through 10, as well as Figure 2) and the Summary Graphs (see Figures 11 through 13, as well as Figure 3) make rather strong statements. If used in an attempt to halt a fleeing suspect, the single-shot nature of the Stun-Gun and the slow flight of the Stun-Bag make a hit unlikely except at relatively close ranges. If a fleeing suspect is hit in any area except the head (a difficult target because of the lack of accuracy demonstrated by the Stun-Bag ammunition), the damage done to the suspect is generally serious but of such a nature that he is mobile, conscious, and still able to flee. This means that injuries are inflicted without performing the job intended for the weapon, i.e., immediately stopping the suspect. Stun-Bags are better used as a means of dispersing crowds, where the desirable effects and undesirable effects as measured by the LWL methodology are roughly equal. However, this still means accepting a high incidence of serious injury to any person hit in the head or trunk areas.

Finally, the analysis revealed, from graphs such as Figure 3 (probability of desirable effect versus probability of undesirable effect), that the Stun-

Bag ammunition/projectile appears to be unsatisfactory at all the ranges considered, i.e., 40-200 feet. At short range, it is unsatisfactory due to the resulting organ damage, while at longer ranges impacting energy/organ damage is less but so are the resulting desirable effects on the targeted individual.

In summary, the Stun-Bag appears to offer little to local police departments as an augmentation to their present standard weapon, the .38 caliber. Analysis of the tests showed that the Stun-Bag's ability to aid the police in apprehending a fleeing suspect or dispersing a crowd is marginal at best and at present does not adequately satisfy police requirements.

I. INTRODUCTION

Efforts of the US Army Land Warfare Laboratory (LWL) to develop less lethal weapons evaluation methodology have centered around blunt-trauma-producing, nonpenetrating weapons. This is because there are increasingly many weapons of this nature on the market and in use by law enforcement agencies, and no satisfactory method has been available for evaluating the performance of such weapons.

The LWL methodology developed to date is presented in a report entitled "A Multidisciplinary Technique for the Evaluation of Less Lethal Weapons."[1] This report is in two volumes: Volume I, or LWL Volume I as it will be referred to herein, carries the same title as the report and introduces the general less lethal weapons evaluation methodology; while Volume II, subtitled "Effectiveness and Safety Characteristics of the .38 Caliber Weapon System,"[2] applies the methodology to the standard .38 caliber police weapon system.

It was decided to analyze the Stun-Bag* as a less lethal projectile (using the aforementioned methodology) because of its growth of popularity as a so-called "nonlethal" weapon, because of its representativeness of a class of these weapons, and because it would serve as a further test of the methodology itself. The general objective of this report, then, is the evaluation of a class of less lethal weapons effectiveness and safety characteristics through the application of the LWL methodology. The specific item selected for study is a collection of ammunition which utilizes the Stun-Bag as the projectile.

The particular goals of the study are to supply:

- o Technical and operational analysis of Stun-Bag ammunition/projectile performance

- o Medical evaluation of damage due to Stun-Bag impacts at particular kinetic-energy levels o Estimates of probabilities of Stun-Bag hits on targets in various scenarios at various ranges**

o Assessment of the likelihood of desirable and undesirable effects from evaluations of Stun-Bag impacts.

As the analysis progressed, it became evident that it was not possible to completely exercise the LWL methodology at this time because of certain insufficiencies in both the methodology and the data. However, discovery of these insufficiencies did serve the useful purpose of indicating that further work is required to make the methodology more usable.

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*Manufactured by MB Associates

**Time and monetary constraints have limited the depth of investigation of this goal. The rest of the goals are examined for two pertinent scenarios, (1) Suspect Fleeing on Foot and (2) Dispersal of a Crowd.

Though it was not possible to perform a complete analysis of the Stun-Bag using the LWL methodology, some test data were acquired from Stun-Bag firings. From the analysis of these data, certain "observations" can be made which are presented in Section III below of the same title.

Thus, in summary, the usefulness of this report is two-fold:

o The results and analyses of Stun-Bag firings vs animal and nonanimal targets are presented, and

o Insufficiencies in the LWL evaluative methodology are brought to light.

II. TECHNICAL APPROACH

The approach taken in this report is to consider the particular items of data necessary to compute simple, useful indices of overall Stun-Bag projectile/ammunition performance. Handling of the data follows the general methodology as described in LWL Volume I, with one exception. The exception is that hit probabilities herein are estimated for the head and body directly, and no use is made of the computational model originally intended for this purpose (LWL Volume I, Appendix G).

Specific treatment is given of the following data:

- Projectile/Ammunition Performance Characteristics
- Scenarios
- Physiological Data
- Nonphysiological Data
- Summarization Indices
- Comparison of Stun-Bag Rounds

The reason for the departure from the established hit probability methodology is that the data bank being developed for the Incapacitation Probability Program (IPP) (reference LWL Volume I, Appendix G) includes parameters which are not available in this study. Among the parameters necessary for this model are standard deviation of ballistic and aiming errors and incapacitation/hit ratios vs velocity of impact. Because of the limited number of Stun-Bag firings made during the animal-testing phase of this study, there is not sufficient data available to reliably predict incapacitation/hit ratios for particular organs and body areas. However, some ballistic error information is available from another Army-sponsored report[3] and from a USALWL-generated study[4]. This background is the justification for the more amalgamated approach to probabilities taken in this report.

The indices which are to form the bases for weapon comparisons are indications of the probability of desirable effects versus the probability of undesirable effects for a particular weapon, in a given operational scenario, for a given range. The parameterization of effects by range is oriented toward the eventual user of these weapons, who is usually more thoroughly familiar with ranging variations than with variations in kinetic energy. Range can, at the same time, be usefully and directly included in both scenarios and computations.

The MB Associates (MBA) Stun-Bag ammunition considered in this study does not represent all of the items of this type offered by MBA. Selections of rounds were made to provide a spectrum of ammunition designed to be effective from relatively close to relatively long range. No real attempt has been made to evaluate, in terms of quality, reliability, etc., the various weapons (such as the Stun-Gun, Prowler-Fouler, etc.) offered by MBA for firing the Stun-Bag.

A. Projectile/Ammunition Performance Characteristics

The Stun-Bag considered in this report consists of a pancake-shaped, three-inch-diameter fabric bag filled with metal shot. This Stun-Bag is available either by itself for use in reloading Stun-Gun cartridge cases (or for use in MBA devices such as the Prowler-Fouler where cartridge cases per se are not required), or it is available as part of a factory-loaded munition which consists of a 40mm cartridge case, a three-inch Stun-Bag, a plastic wad, a cardboard disk and a predetermined gunpowder charge or load.

In order to illustrate velocity and ranging information, three factory-loaded rounds were chosen and were designated as A, B, and C (Table I). The difference in rounds is the gunpowder charge or load used to fire the particular Stun-Bag, resulting in different initial velocities and extreme ranges. Due to the limited amount of data available, the velocities given in Table I are nominal figures. The rounds chosen cover a wide delivery range, i.e., zero to 355 feet.

An additional feature of the three-inch Stun-Bag is that it is available in two different weights: the first weight is around .35 lb and is the approximate weight of the Stun-Bag found in factory-loaded ammunition; the second weight is around .42 lb and is the weight of the Stun-Bag available for reloading, etc. purposes. Variations in these weights were observed in various firings and are summarized in Table II. Also, since variation in Stun-Bag weights affects kinetic energy delivered to a target, Tables III-V have been prepared to show this effect over a spectrum including all observed weights.

The flight characteristics of a projectile depend on its initial velocity, weight, shape, firing cross-section, and the density of air. From assumption of typical values for Stun-Bag weights and initial velocities, a numerical integration procedure (See Appendix A) was used to compute trajectories of Stun-Bags fired at different angles. For illustration, some of the results of these calculations are shown in a trajectory chart, Figure 4. The trajectory chart represents the firing of three different rounds (Rounds A, B, and C) from five feet above the ground at angles of zero and fifteen degrees. The dots which trace the projectile path are the computed positions of the projectile at approximately .05-second intervals*. The small "x" at the end of each trajectory indicates the location (range) of the projectile when it strikes the ground.

The Ranging Tables VI-VIII are also derived from the numerical-integration calculation of trajectory. It is important to analyze the velocity and range of the Stun-Bag or any blunt-trauma-producing projectile in terms of its delivery to a region near the ground (zero to six feet height) where a target may be hit. This zone might be called the effective impact region. Ranging Tables VI-VIII record typical values of time, distance, velocity, and kinetic-

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*The reason the fifteen-degree firings seem to show an angle of greater than fifteen degrees is that there is a scale reduction in range of six-to-one, as compared to height, in the figure.

TABLE I

FACTORY-LOADED STUN-BAG ROUNDS TESTED

(Three-inch, circular Stun-Bag - avg wt = 0.35 lb)

Round A - Super Long-Range Round

initial velocity	-	230 feet per second
extreme range	-	355 feet

Round B - Low Impact Round

initial velocity	-	150 feet per second
extreme range	-	255 feet

Round C - Close Range Round

initial velocity	-	100 feet per second
extreme range	-	200 feet

TABLE II

STUN-BAG WEIGHTS

Tests	No. of Bags	Mean Weight (lb)	Standard Deviation (lb)	Low (lb)	High (lb)
LWL Animal Tests (Baboons), Dec 72	23	.424	.0095	.405	.438
LWL Animal Tests (Swine), Dec 72	25	.418	.0052	.406	.425
LWL Performance Tests, Apr 73	17	.317	.0061	.295	.323

TABLE III

KINETIC-ENERGY DELIVERY

(Super Long-Range Round)

Range (ft)	Velocity (ft/sec)	Kinetic Energy Per Pound (ft-lb)	Kinetic Energy (ft-lb) as a Function of Bag Weight				
			.30 lb	.35 lb	.40 lb	.45 lb	.50 lb
0	230	822.2	246.7	287.8	328.9	370.0	411.1
20	210	685.4	205.6	239.9	274.2	308.4	342.7
40	190	561.1	168.3	196.4	224.4	252.5	280.5
60	175	476.0	142.8	166.6	190.4	214.2	238.0
80	163	412.9	123.9	144.5	165.2	185.8	206.5
100	150	349.7	104.9	122.4	139.9	157.4	174.9
120	138	296.0	88.8	103.6	118.4	133.2	150.0
150	122	231.3	69.4	81.0	92.5	104.1	115.7
180	108	181.3	54.4	63.5	72.5	81.6	90.6
200	99	152.3	45.7	53.3	60.9	68.5	76.2
250	84	109.7	32.9	38.4	43.9	49.4	54.9
300	69	74.0	22.2	25.9	29.6	33.3	37.0

51,3

TABLE IV

KINETIC-ENERGY DELIVERY

(Low Impact Round)

Range (ft)	Velocity (ft/sec)	Kinetic Energy Per Pound (ft-lb)	Kinetic Energy (ft-lb) as a Function of Bag Weight				
			.30 lb	.35 lb	.40 lb	.45 lb	.50 lb
0	150	349.7	104.9	122.4	139.9	157.4	174.9
20	138	296.0	88.8	103.6	118.4	133.2	148.0
40	127	250.7	75.2	87.7	100.3	112.8	125.3
60	117	212.8	63.8	74.5	85.1	95.7	106.4
80	105	171.4	51.4	60.0	68.5	77.1	85.7
100	99	152.3	45.7	53.3	60.9	68.5	76.2
120	95	140.3	42.1	49.1	56.1	63.1	70.1
150	81	102.0	30.6	35.7	40.8	45.9	51.0
180	72	80.6	24.2	28.2	32.2	36.3	40.3
200	67	69.8	20.9	24.4	27.9	31.4	34.9
250	64	63.7	19.1	22.3	25.5	28.6	31.8

51,4

TABLE V

KINETIC-ENERGY DELIVERY

(Close Range Round)

Range (ft)	Velocity (ft/sec)	Kinetic Energy Per Pound (ft-lb)	Kinetic Energy (ft-lb) as a Function of Bag Weight				
			.30 lb	.35 lb	.40 lb	.45 lb	.50 lb
0	110	188.1	56.4	65.8	75.2	84.6	94.1
20	101	158.5	47.6	55.5	63.4	71.3	79.3
40	94	137.3	41.2	48.1	54.9	61.8	68.7
60	85	112.2	33.7	39.3	44.9	50.5	56.2
80	80	99.5	29.9	34.8	39.8	44.8	49.8
100	73	82.8	24.8	29.0	33.1	37.3	41.4
120	67	69.8	20.9	24.4	27.9	31.4	34.9
150	62	59.7	17.9	20.9	23.9	26.9	29.9
180	59	54.1	16.2	18.9	21.6	24.3	27.1

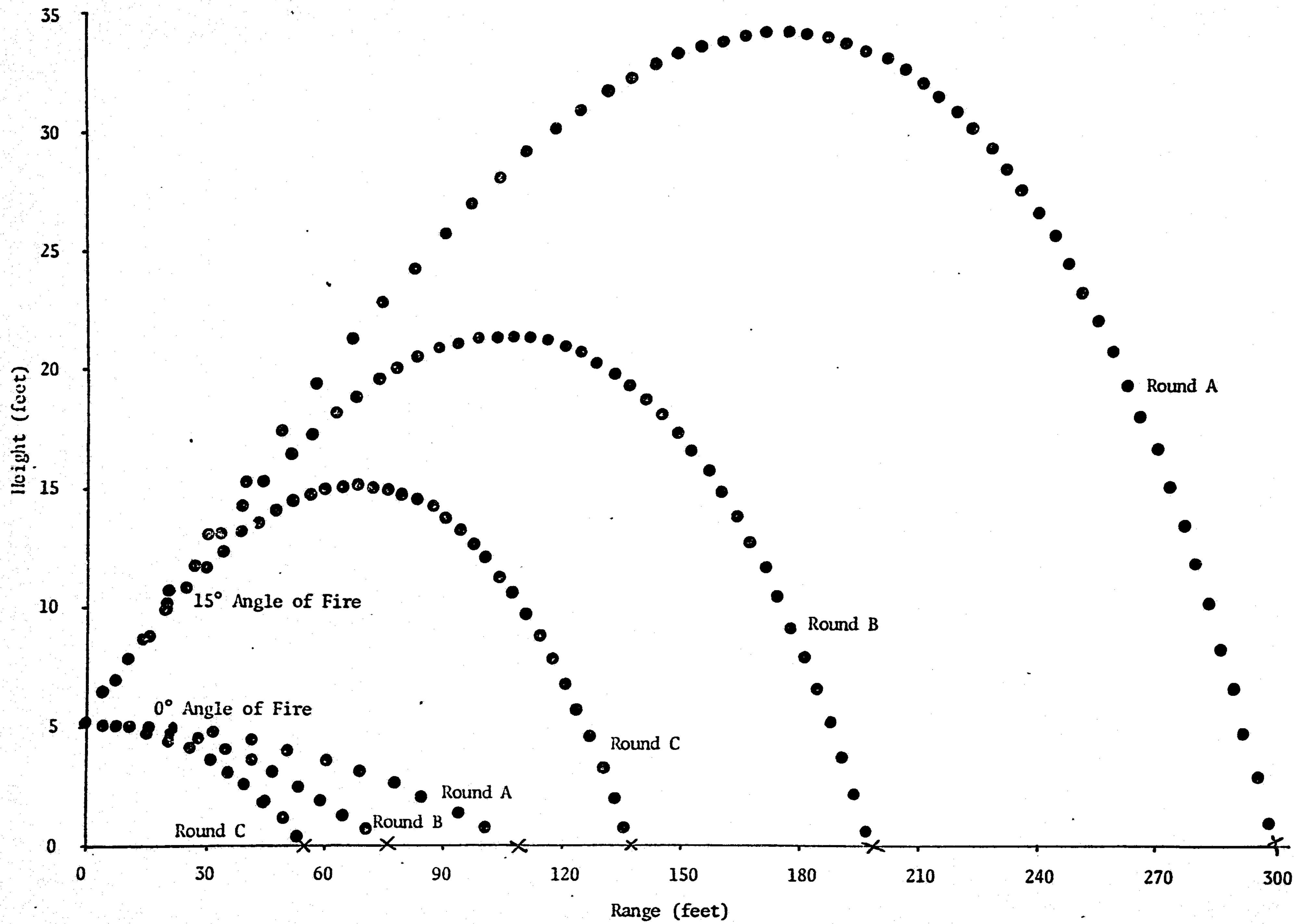

FIGURE 4. Trajectory Chart--0° and 15° Angle of Fire

51,5

TABLE VI

RANGING TABLE

(Super Long-Range Round)

Firing Angle* (ft)	High Point (ft)	Range** (ft)		Time** (sec)		Velocity** (ft/sec)		Kinetic Energy Per Pound** (ft-lb)	
		begin	end	begin	end	begin	end	begin	end
0	5.0	0	106	0.00	0.60	230.0	147.0	822.2	335.9
5	9.6	161	196	1.00	1.33	118.0	102.5	216.4	163.3
10	20.4	245	262	1.88	2.09	84.9	81.3	112.0	102.7
15	34.2	291	300	2.61	2.78	72.8	72.0	82.4	80.6
20	50.6	322	328	3.28	3.40	68.6	68.9	73.1	73.8
25	68.1	340	345	3.85	3.96	67.9	68.5	71.7	73.0
30	87.6	352	355	4.41	4.51	69.1	69.9	74.2	75.9
35	107.1	354	357	4.91	5.00	70.7	71.4	77.7	79.3
40	126.8	349	352	5.38	5.49	72.5	73.4	81.7	83.7
45	146.1	338	340	5.81	5.90	74.4	75.0	85.6	87.4

*Firing from five feet above ground
**Range, time, velocity and kinetic-energy measure were taken on the edge of the effective hitting region--five/six (begin) and zero (end) feet above ground, respectively.

51,6

TABLE VII

RANGING TABLE

(Low Impact Round)

Firing Angle* (ft)	High Point (ft)	Range** (ft) begin	Range** (ft) end	Time** (sec) begin	Time** (sec) end	Velocity** (ft/sec) begin	Velocity** (ft/sec) end	Kinetic Energy Per Pound** (ft-lb) begin	Kinetic Energy Per Pound** (ft-lb) end
0	5.0	0	75	0.00	0.57	150.0	110.5	349.7	189.8
5	7.3	81	122	0.65	1.07	106.0	91.0	174.6	128.7
10	13.1	145	165	1.36	1.62	82.0	77.4	104.5	93.1
15	21.4	186	199	1.96	2.16	70.9	69.5	78.1	75.1
20	31.6	214	223	2.55	2.68	65.7	65.7	67.1	67.1
25	43.1	233	240	3.01	3.15	63.7	64.4	63.1	64.5
30	55.5	246	250	3.47	3.59	63.6	64.5	62.9	64.7
35	68.5	251	255	3.90	4.00	64.5	65.4	64.7	66.5
40	81.7	251	254	4.29	4.40	65.8	66.9	67.3	69.5
45	94.9	246	249	4.66	4.76	67.4	68.4	70.6	72.7

*Firing from five feet above ground
**Range, time, velocity and kinetic-energy measure were taken on the edge of the effective hitting region--five/six (begin) and zero (end) feet above ground, respectively.

TABLE VIII

RANGING TABLE

(Close Range Round)

Firing Angle* (ft)	High Point (ft)	Range** (ft)		Time** (sec)		Velocity** (ft/sec)		Kinetic Energy Per Pound** (ft-lb)	
		begin	end	begin	end	begin	end	begin	end
0	5.0	0	56	0.00	0.58	110.0	88.3	188.1	121.2
5	6.3	40	84	0.40	0.92	92.4	78.7	132.7	96.3
10	9.8	91	113	1.02	1.34	75.0	70.6	87.4	77.5
15	15.1	124	138	1.53	1.78	66.5	65.1	68.7	65.9
20	21.8	147	157	1.99	2.16	61.7	61.8	59.2	59.4
25	29.5	164	172	2.42	2.58	59.4	60.2	54.8	56.2
30	37.9	175	182	2.80	2.98	58.6	60.0	53.4	56.0
35	46.9	183	187	3.16	3.31	58.9	60.3	53.9	56.5
40	56.1	184	188	3.51	3.63	59.7	61.1	55.4	58.0
45	75.7	244	249	4.16	4.26	78.1	80.0	94.8	99.5

*Firing from five feet above ground
**Range, time, velocity and kinetic-energy measure were taken on the edge of the effective hitting region--five/six (begin) and zero (end) feet above ground, respectively.

energy measure of entry ("begin") into this region, and the time, distance, velocity, and kinetic-energy measure of impact ("end") with the ground.

When discussing projectile/ammunition performance, it is also necessary to consider the associated ballistic error and operational accuracy/aiming error. In order to generate some information on the ballistic error associated with the Stun-Bag, a limited number of test firings were conducted by H. P. White Laboratory for USALWL. For these test firings the MBA Stun-Gun and factory-loaded Stun-Bag ammunition were used. The Stun-Gun was clamped firmly into position (bench-mounted) and bore-sighted to a reference point on a paper target. Some of the results of this testing are shown in Table IX. While values for mils of error are difficult to estimate with such a limited amount of data available, a horizontal error of approximately four mils and a vertical error of approximately seven mils can be inferred from the data.

Additionally, a few more rounds were fired at seven yards and 25 yards (employing the Stun-Gun in a hand-held position and again using factory-loaded Stun-Bag ammunition)* to obtain a rough estimate of the operational accuracy, i.e., including the aiming error introduced when combining the man and weapon system. In this situation the horizontal error showed a minimal amount of increase to five mils; however, the vertical error showed a large increase to 19 mils[5].

If a target is to be hit, it is also essential to estimate the speed and position of the target, and to elevate sufficiently the weapon/firing device so that the projectile and the target arrive in the effective impact region at the same time. Since the greatest initial velocity for the factory-loaded ammunition considered in this report (Super Long-Range Round) is 230 feet per second (about the speed of a batted baseball), the difficulty of hitting a target at appreciable distances may be appreciated. When using Round A, for example, to hit a target at 175 feet, it is necessary to estimate the position of the target 1.2 seconds from the moment of fire.

In summary, the lack of accuracy demonstrated by the Stun-Bag ammunition will very likely restrict its usefulness for law enforcement officials. This fact is especially apparent when comparing Stun-Bag accuracy performance with .38 caliber accuracy performance.

B. Scenarios

Selection of scenarios is a key element in the evaluation of less lethal weapons. In LWL Volume I the following four scenarios were chosen as bases for comparison among different weapons or devices. (Detailed descriptions of the scenarios can be found in Appendix C of the aforementioned report.)

- Scenario I - The One-on-One Situation

- Scenario II - The Barricade and Hostage Situation

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*The individual who did the firing is an experienced shooter who had previously fired a military weapon similar to the Stun-Gun.

TABLE IX

STUN-BAG BALLISTIC ERRORS

Ammunition	No. of Rounds	Range (ft)	μ_h (in)	σ_h (mils*)	μ_v (in)	σ_v (mils*)	σ_t (mils*)
Stun-Bag, Close Range	3	21	-0.97	3.77	- 5.00	8.65	6.67
Stun-Bag, Low Impact	3	21	-1.63	4.68	- 5.67	6.07	5.42
Stun-Bag, Super Long-Range	4	75	-3.00	3.39	-29.55	7.33	5.71

NOTE: h = horizontal
v = vertical
t = target
μ = mean miss distance
σ = standard deviation of miss distances

*At a range of 21 feet, one mil is 0.25 inches; at a range of 75 feet, one mil is 0.90 inches

- Scenario III - The Suspect Fleeing on Foot
- Scenario IV - The Dispersal of a Crowd.

The Stun-Bag projectile was considered by the members of the Less Lethal Weapons Evaluation Panel to be generally applicable for use in all of the above-mentioned scenarios. However, there was some question regarding the use of the Stun-Gun in its present form. It was thought that at very close ranges the Stun-Gun would be clumsy to use, particularly in comparison with a handgun. It was also felt that the single-shot restriction of the Stun-Gun would be a serious hindrance to the police officer.

Use of the Stun-Bag projectile was evaluated by the Medical Group and the Behavior Analysis (formerly Methods) Group of the basic Evaluation Panel for two of the four scenarios, namely, the Suspect Fleeing on Foot and the Dispersal of a Crowd Scenarios. (Funding limitations precluded evaluating use of the Stun-Bag for the two remaining scenarios.) The results of these evaluations can be found in Section C below; when combined with estimates of hit probabilities, the results are found in Section E.

C. Physiological Data

A two-part test series was conducted impacting the three-inch-diameter Stun-Bags against animals[6]. The first part, impacting Stun-Bags against baboons, provided examples of cranial impacts; the second part, impacting the Stun-Bag against swine, provided examples of body impacts for several major organs. Both portions of the test included as part of the results the effects of the impacts on skin, bone and subcutaneous tissue.

Several facts about the circumstances of the animal testing should be mentioned. First, the tests were conducted using an air-gun-type system firing a three-inch Stun-Bag of approximately .42 lb at velocities ranging from about 50 feet per second to 135 feet per second (These velocities were chosen to encompass the "15, 30, 60 and 90 ft-lb" kinetic energy criteria established in LWL Volume I to indicate various degrees of physiological damage.). Second, baboons were chosen as test animals to represent cranial effects of Stun-Bag impacts. Cranial size and armoring of a baboon and of a man have been judged to be closely comparable. A possible exception is the formation of the posterior skull of the baboon, which is shaped differently from that of a man and includes a thickened area not found in man. Shots involving the posterior area of the skull may not, therefore, fully represent the nature and extent of damage that can be done to a man by an impact in this area. Third, swine (actually young shoats) were chosen as targets to represent bodily effects of Stun-Bag impacts. Although goats have previously been used in some evaluations, it was the opinion of the Medical Group that the relative weights of the body organs of the shoats were more comparable to those of man and the skin of the shoats was considered to be a great deal more comparable to man than that of goats.

The Medical Group of the Less Lethal Weapons Evaluation Panel performed the assessment of physiological damage due to Stun-Bag impacts. Records of the physiological effects were made first in terms of damage levels on a scale from zero to five; then, estimates were made of the probability of the damage level observed achieving a physiological undesirable or desirable effect for the scenarios addressed. A summary of the test shots (in order of increasing impact energy) and subsequent evaluations of the shot impacts (incorporating both the Medical Group and Behavior Analysis Group estimates) is contained in Tables X and XI.

One significant fact that was noted was that damage to the liver usually dominated the overall physiological effects whenever there was any involvement of damage to that organ. A full account of the deliberations on these data is contained in Appendix B.

D. Nonphysiological Data

Prior to rendering estimates of probability of desirable effect, the Behavior Analysis Group of the Less Lethal Weapons Evaluation Panel attempted to quantify the emotional make-up of crowd members (During a previous meeting they had addressed the area of an individual's emotional level.). At the same time, they attempted to identify the types of crowds that might be encountered.

Following the above discussions, estimates were rendered of probability of nonphysiologically (psychologically) desirable effects for the scenarios under consideration. A full account of these deliberations is contained in Appendix C.

E. Summarization Indices

The particular graphic form chosen to display "weapon" performance in the aforementioned methodology (LWL Volume I) is also used in this report for two purposes. The two purposes are: (1) to display the results of the actual test data, and (2) to display the expected performance of a particular ammunition as a function of range.

The chosen graphic form plots the probability of an undesirable effect (P_{UE}) against the probability of a desirable effect (P_{DE}). Plotting both of these values together for a single impact in effect describes the price paid in terms of P_{UE} in order to achieve a certain level of P_{DE}.

The first use of this form of graph is to present the results of P_{UE} and P_{DE} evaluations performed by the Medical and Behavior Analysis Groups. These results are displayed in Figures 5 through 10 and represent the same data as the Test Shot Summary Sheets, Tables X and XI; but the data are broken down according to three levels of kinetic energy, namely, low (10-39 ft-lb), medium (40-74 ft-lb), and high (75-125 ft-lb). The figures show the probable effects (both P_{DE} and P_{UE}) of Stun-Bags if they do in fact reach a target.

TABLE X

TEST SHOT SUMMARY SHEET

(Baboons)

Animal No.	Velocity (ft/sec)	Energy (ft-lb)	Target Area	Damage Grade Skin	Damage Grade Head	P_{UE}	P_{DE} III*	P_{DE} IV*
324	47.5	11.9	Anterior Head	0	0	0.0	0.0	0.1
302	49.5	15.5	Left Temple	0	0	0.0	0.0	0.0
325	52.7	18.5	Posterior Head	2	0	0.1	0.0	0.0
323	58.0	22.8	Left Temple	0	0	0.0	0.0	0.0
306	60.9	23.7	Anterior Head	0	1	0.0	0.0	0.0
305	60.8	24.4	Anterior Head	0	2	0.0	0.0	0.0
316	62.0	25.2	Posterior Head	1	3	0.75	0.75	0.25
304	68.9	25.7	Posterior Head	0	1	0.1	0.1	0.0
301	63.9	26.9	Left Temple	2	0	0.0	0.0	0.0
303	69.7	31.1	Posterior Head	0	2	0.1	0.0	0.1
309	87.9	50.6	Left Temple	2	1	0.2	0.1	0.1
311	90.8	54.1	Left Temple	4	0	1.0	1.0	0.9
307	93.0	55.5	Anterior Head	0	0	0.0	0.0	0.0
308	95.8	59.6	Anterior Head	2	1	0.25	0.1	0.1
310	95.8	59.9	Left Temple	3	1	0.2	0.5	0.5
314	95.8	62.1	Posterior Head	3	3	1.0	1.0	0.9
317	102.0	69.1	Anterior Head	4	5	1.0	1.0	0.0
322	102.0	70.0	Left Temple	2	0	0.2	0.1	0.1
313	102.0	70.7	Posterior Head	0	3	0.5	0.5	0.75
312	109.0	78.1	Left Temple	4	1	0.75	0.5	0.9
320	109.0	79.8	Left Temple	3	0	0.5	0.1	0.25
315	120.0	96.0	Posterior Head	3	2	0.5	0.9	0.75
319	120.0	98.1	Left Temple	0	0	0.8	0.5	0.5
318	123.0	99.0	Anterior Head	2	2	0.25	0.5	0.5
321	136.0	124.8	Posterior Head	0	0	0.0	0.0	0.0

*Denotes scenario number

TABLE XI

TEST SHOT SUMMARY SHEET

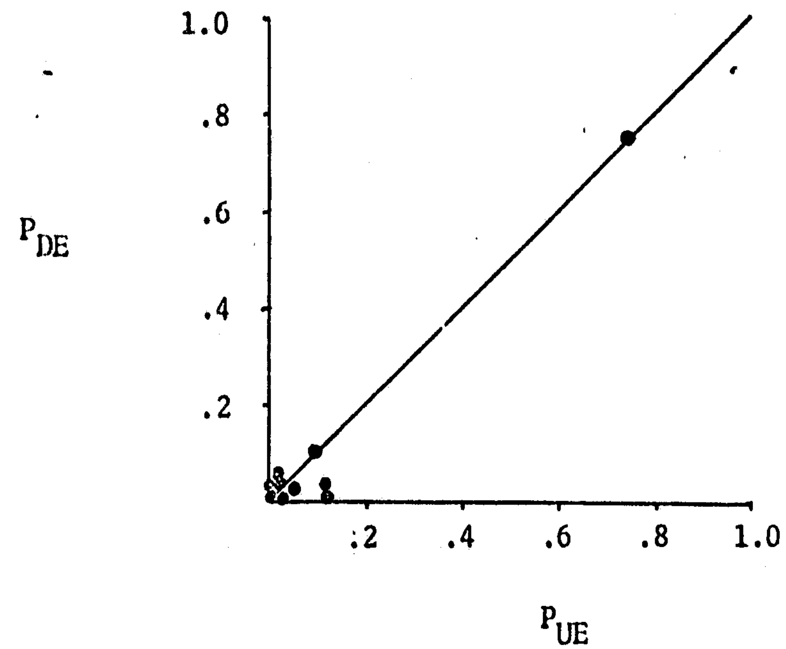
(Swine)

Animal No.	Velocity (ft/sec)	Energy (ft-lb)	Target Area	Damage Grade Skin	Liver	Kidney	Spleen	Lung	Bone	Heart	Other	P_{UE}	P_{DE} III*	P_{DE} IV*
307	54.8	19.3	Kidney	1		0						0.0	0.0	0.0
305	59.0	22.8	Liver	1	3							0.5	0.0	0.5
306	59.1	22.8	Liver	0	1						2	0.1	0.0	0.1
312	59.0	23.0	Kidney	3		4						0.75	0.1	0.5
314	60.0	23.5	Thorax	2	2			2	2	0		1.0	0.25	0.0
324	67.8	29.4	Spleen	0			0				2	0.5	0.0	---
311	79.2	39.7	Kidney	1	5	0						1.0	0.25	0.75
316	81.4	43.4	Thorax	1	4			2		0		1.0	0.1	0.9
304	85.2	47.2	Liver	1	4							1.0	0.25	0.75
318	85.2	47.3	Thorax	3	0			2	2	0		1.0	0.5	0.9
317	85.2	47.9	Thorax	2	4	2		2		0		1.0	0.25	0.75
315	95.7	59.5	Thorax	5				2	2	0		0.5	0.1	0.0
320	96.0	60.2	Spleen	2			0					0.0	0.0	0.1
302	95.8	60.4	Liver	2	4			2	3			0.9	0.25	0.75
309	95.8	60.5	Kidney	3		4						0.75	0.0	0.75
319	98.8	63.7	Spleen	3	4		0					1.0	0.1	0.75
301	100.0	65.3	Liver	0	3					5		1.0	1.0	0.0
323	102.0	67.1	Spleen	2			0	2			1	0.75	0.1	0.5
325	102.0	68.1	Thigh	2					0			0.25	0.0	0.25
303	102.0	68.6	Liver	2	4							1.0	0.25	0.75
322	109.0	75.0	Spleen	3			2				2	0.5	0.0	0.5
321	109.0	75.9	Spleen	3	3		1					1.0	0.25	0.75
308	109.0	76.8	Kidney	4		0						0.5	0.1	0.9
310	109.5	77.3	Kidney	4		4						1.0	0.25	0.9
313	113.0	82.8	Thorax	4	3			2		0		1.0	1.0	0.0

*Denotes scenario number

Head Shots--Low Energy
[10-39 foot-pounds (10) shots]

Scenario III,
Suspect Fleeing
on Foot



Scenario IV,
Dispersal of
a Crowd

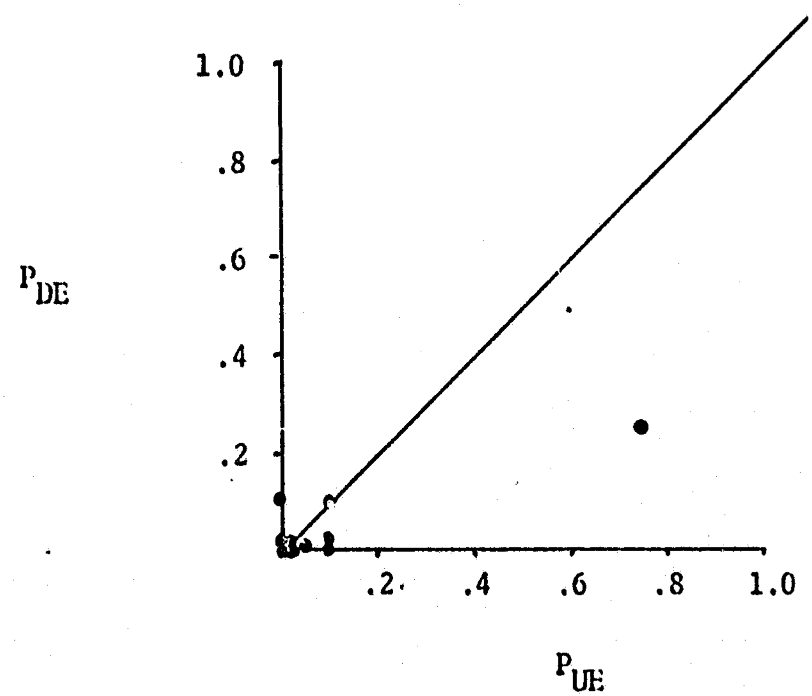
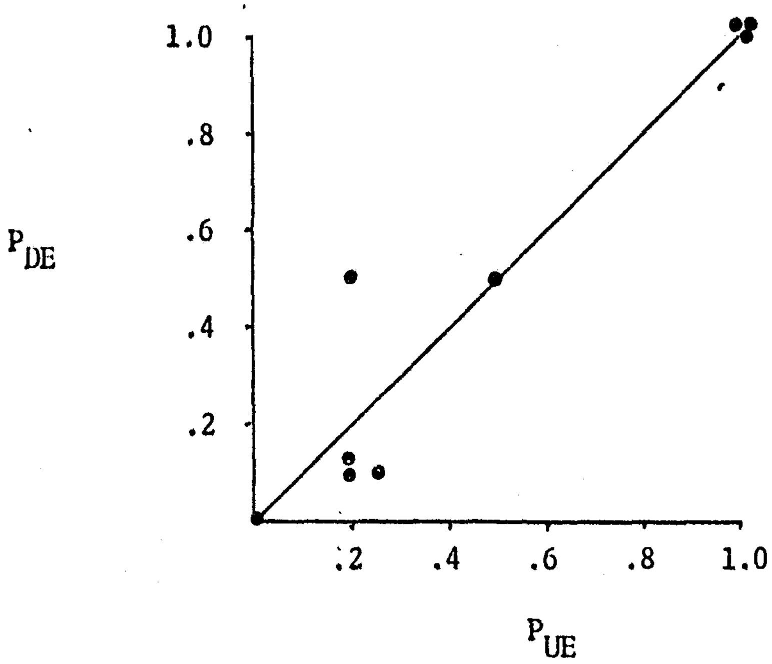


FIGURE 5. Damage Profile Graphs

Head Shots--Medium Energy
[40-74 foot-pounds (9 shots)]

Scenario III,
Suspect Fleeing
on Foot



Scenario IV,
Dispersal of
a Crowd

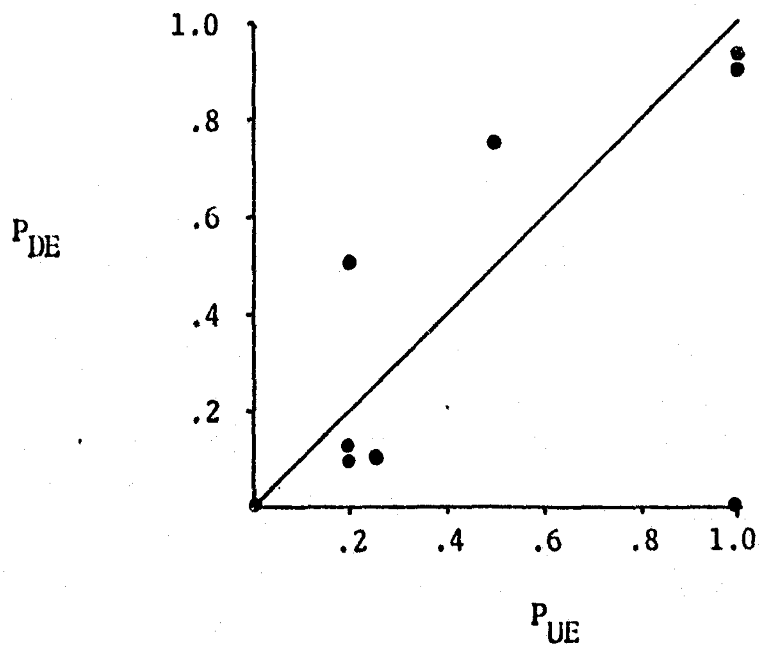
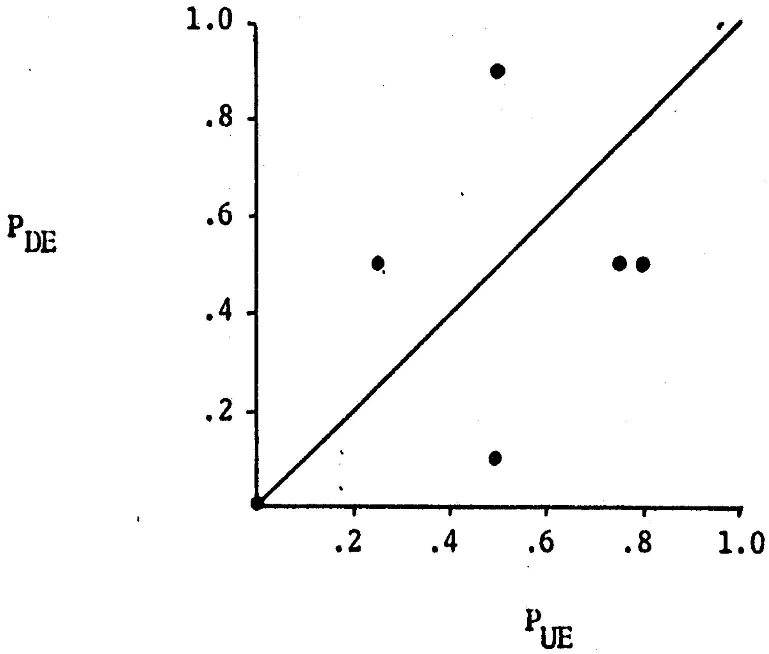


FIGURE 6. Damage Profile Graphs

Head Shots--High Energy
[75-125 foot-pounds (6 shots)]

Scenario III,
Suspect Fleeing
on Foot



Scenario IV,
Dispersal of
a Crowd

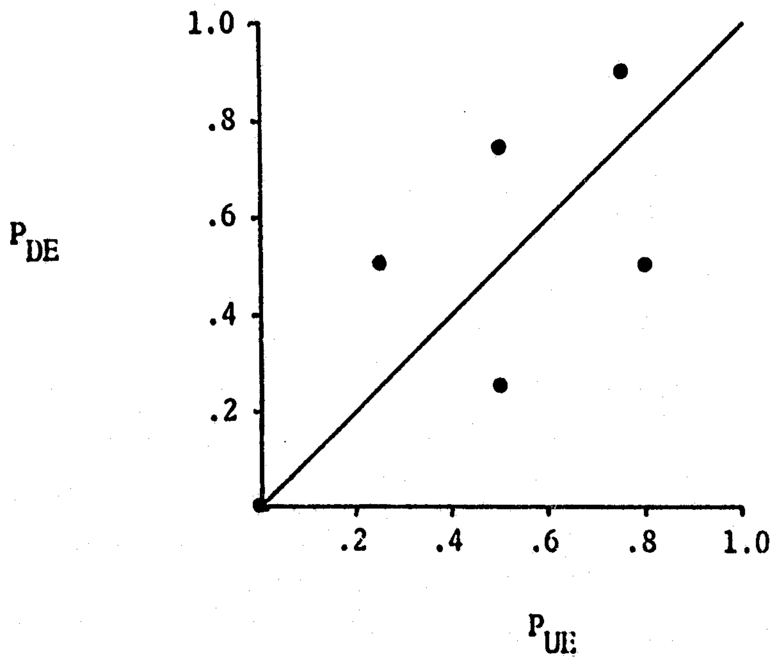
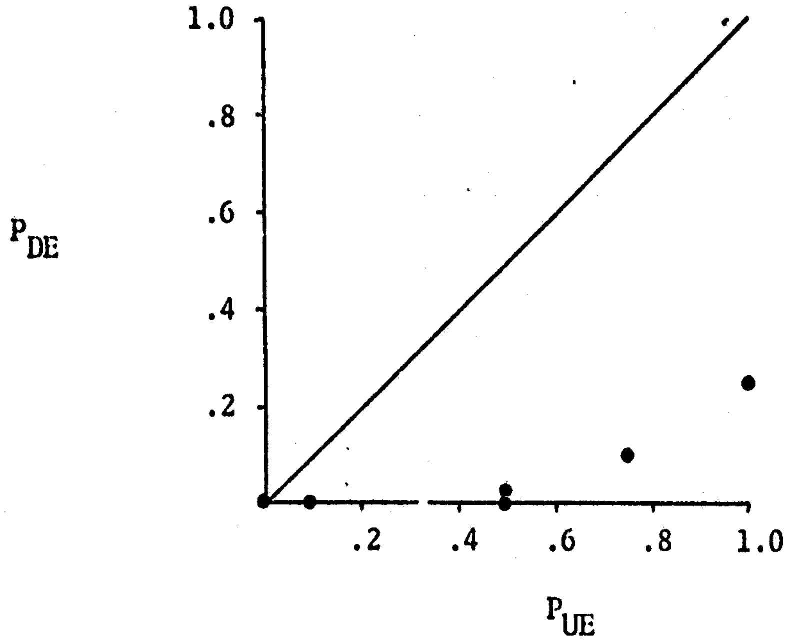


FIGURE 7. Damage Profile Graphs

Body Shots--Low Energy
(10-39 foot-pounds)

Scenario III,
Suspect Fleeing
on Foot (6 shots)



Scenario IV,
Dispersal of
a Crowd (5 shots)

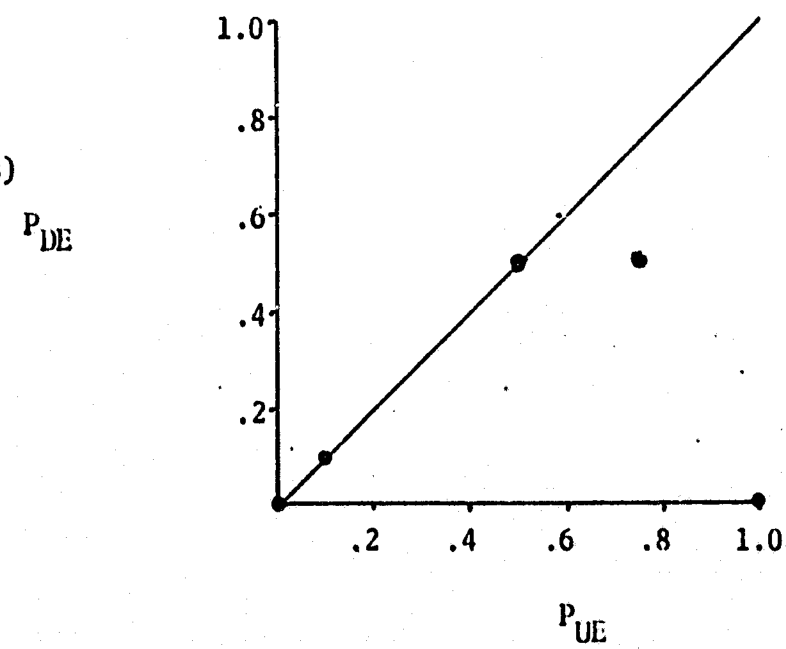
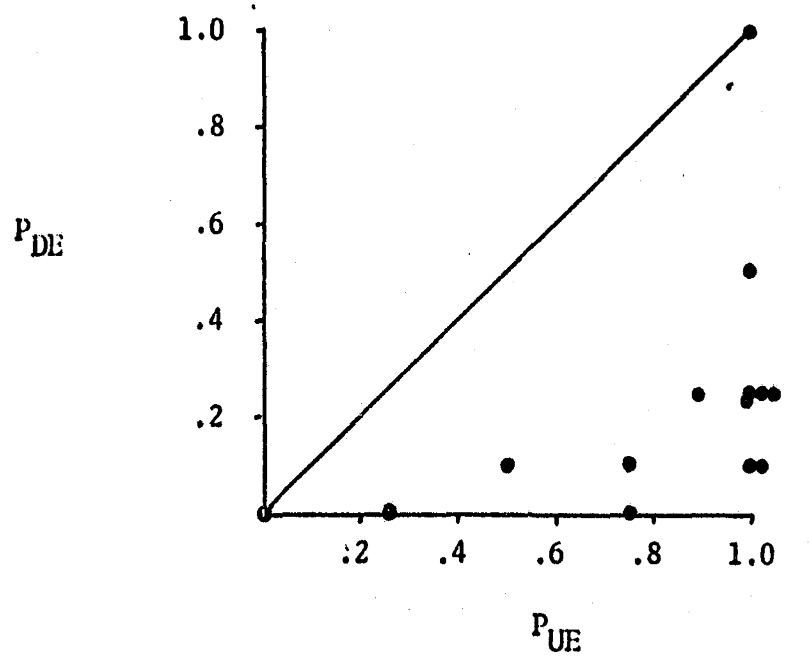


FIGURE 8. Damage Profile Graphs

Body Shots--Medium Energy
[40-74 foot-pounds (14 shots)]

Scenario III,
Suspect Fleeing
on Foot



Scenario IV,
Dispersal of
a Crowd

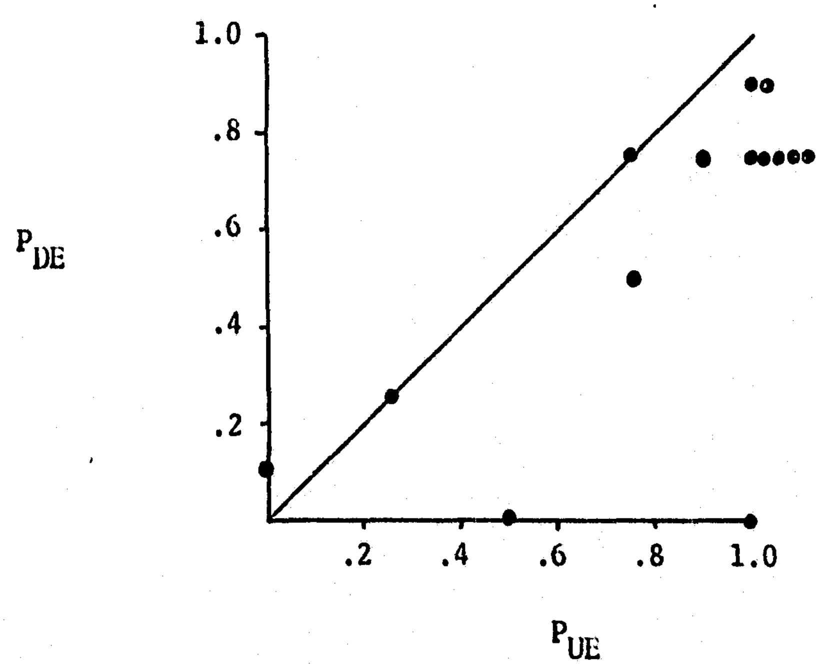
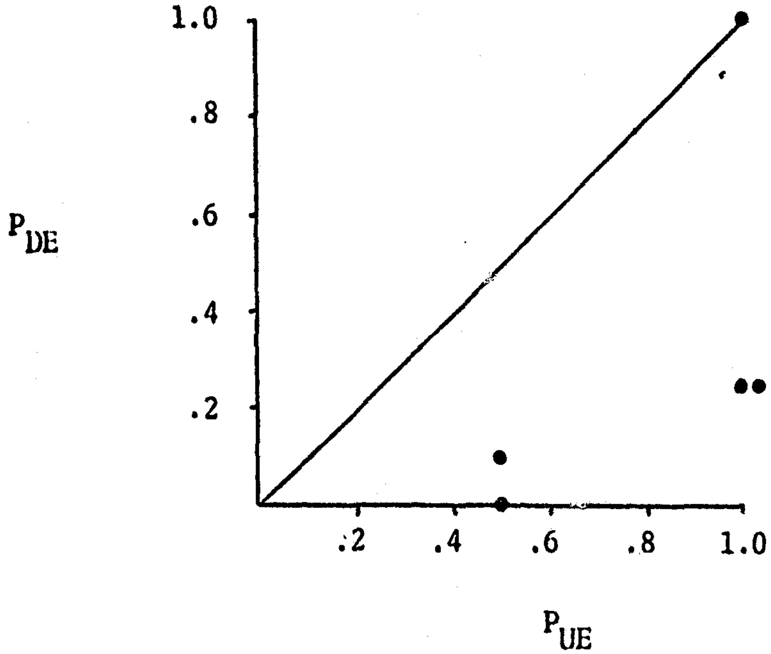


FIGURE 9. Damage Profile Graphs

Body Shots--High Energy
[75-125 foot-pounds (5 shots)]

Scenario III,
Suspect Fleeing
on Foot



Scenario IV,
Dispersal of
a Crowd

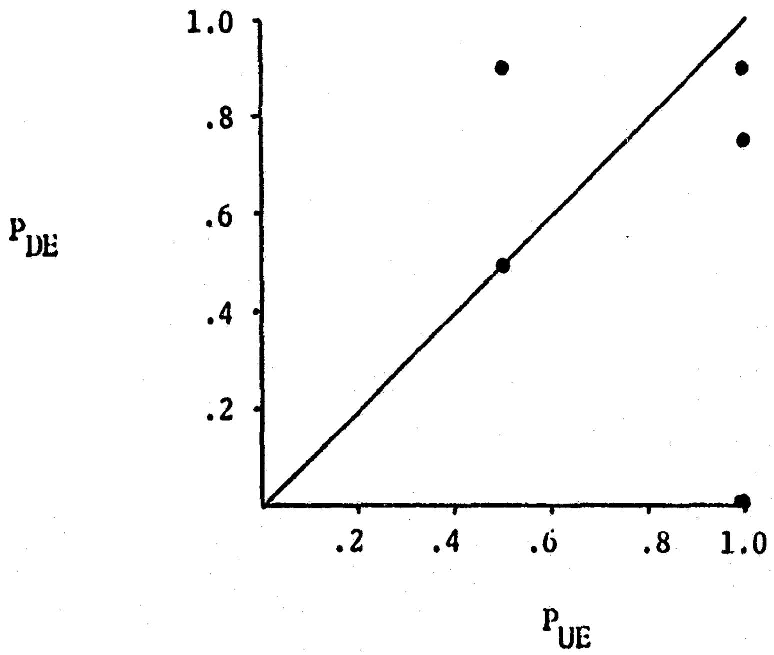


FIGURE 10. Damage Profile Graphs

Clustering of points in this graphical presentation suggest a number of possible conclusions. In general, head shots in a low-energy range, 10 to 39 foot-pounds, appear to have little effect (Figure 5). From Figures 6 and 7, medium- and high-energy head impacts show roughly equal probability of undesirable and desirable effect (Note the fairly even distribution of data points above and below the equal-probability line.). Body shot results for the medium kinetic-energy level (Figure 9) make prediction of effects from similar shots fairly reliable. However, based on limited data available, body shots for low- and high-energy levels (Figures 8 and 10) permit less reliable prediction of effects. These areas probably deserve more intensive study.

The second use of this graphic format is to exhibit performance of the three representative types of ammunition as a function of range. These Summary Graphs are shown in Figures 11 through 13 and are based on calculations detailed in Appendix A. A feature of these graphs is that they take into account the limitation of the ammunition utility due to low probabilities of accurate delivery.

Briefly, computations supporting the Summary Graphs involve extrapolating probabilities of effect from Test Shot Summary Sheets; estimating hit probabilities by the formula:

$$P_{hit} = \frac{A_t}{A_t + 2\pi\sigma_h\sigma_v} ,$$

where A_t is the total presented body area and σ_h and σ_v are the horizontal and vertical miss distances (standard deviations), respectively; and computing the probabilities of effect on the body.

F. Comparison of Stun-Bag Rounds

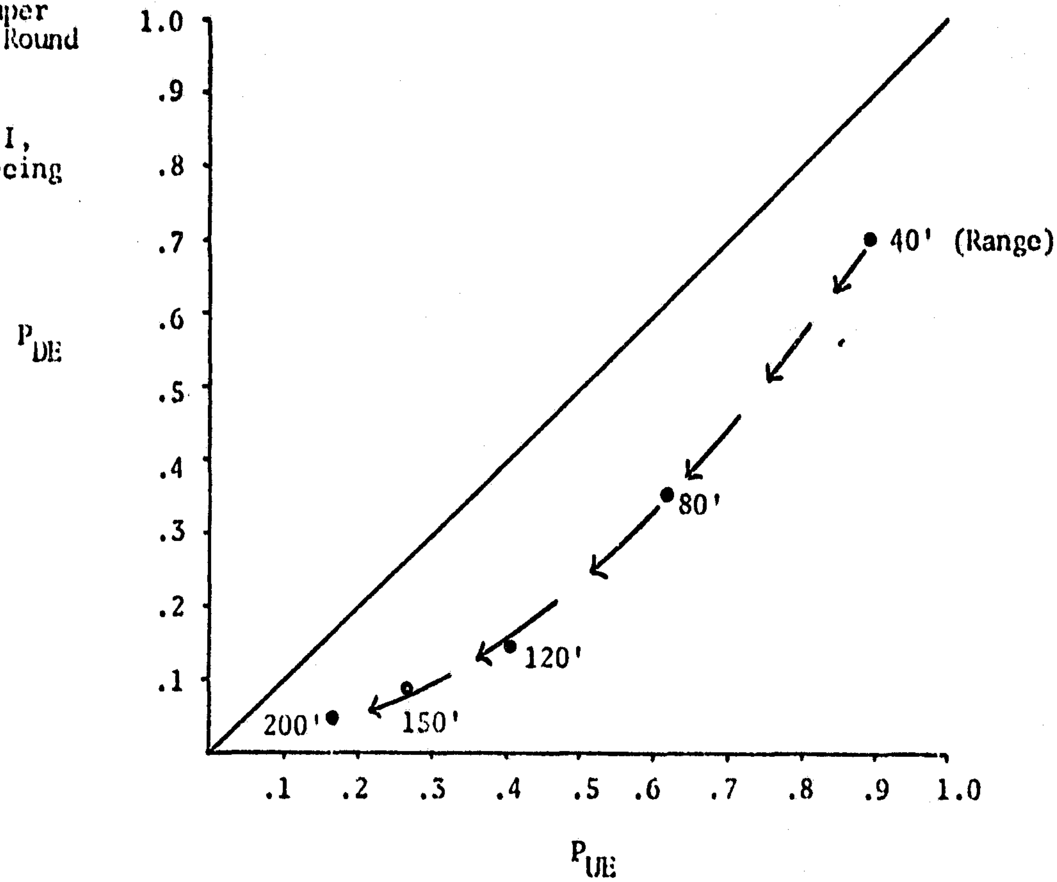
Comparisons of the three rounds considered in this report show that none of these rounds in either scenario at any range for which computations were made have a probability of desirable effects greater than the probability of undesirable effects. This means that Stun-Bag rounds may be expected to extract a high price in terms of undesirable effects in order to produce performance in terms of desirable effects.

In Scenario III for ranges under approximately 75 or 80 feet, Round A has probabilities of desirable effects exceeding .4, but probabilities of undesirable effects range from approximately .65 to .9. Neither Round B nor Round C provide even the .4 level of "stopping power" at any range considered in this scenario.

FIGURE 11. Summary Graph (P_{DE} vs P_{UE} as a Function of Range)

Round A--Super Long-Range Round

Scenario III, Suspect Fleeing on Foot



Scenario IV, Dispersal of a Crowd

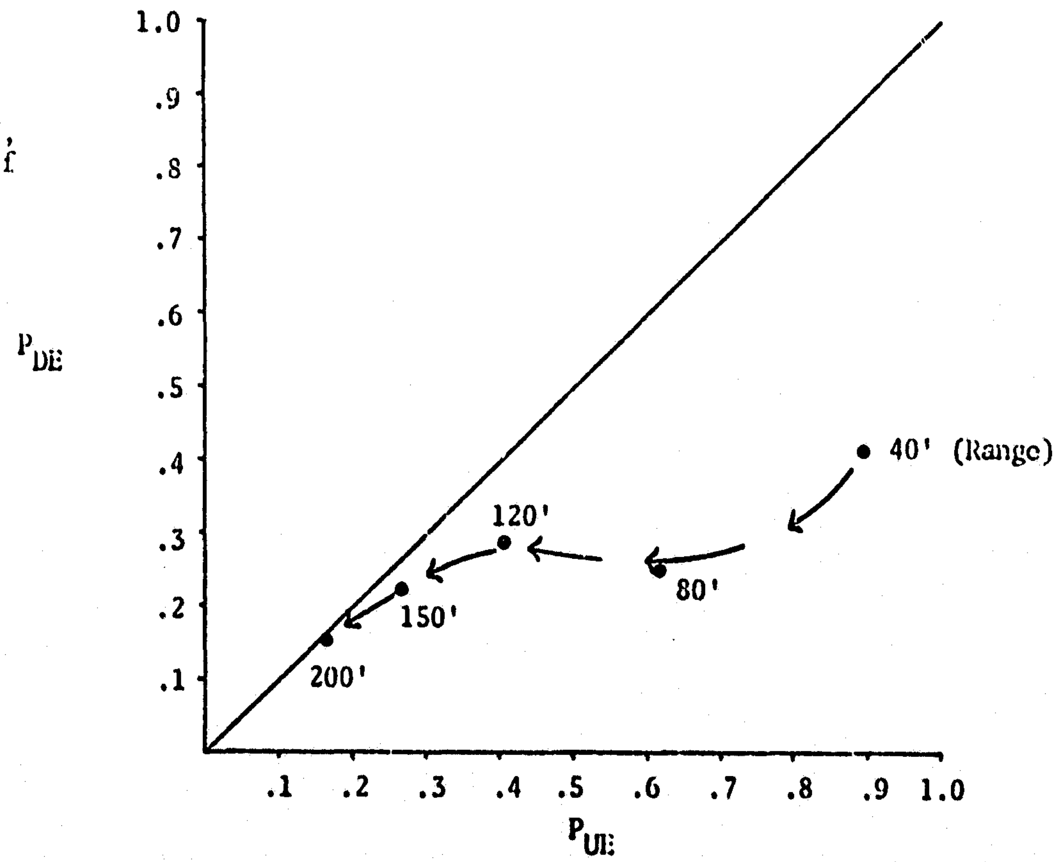
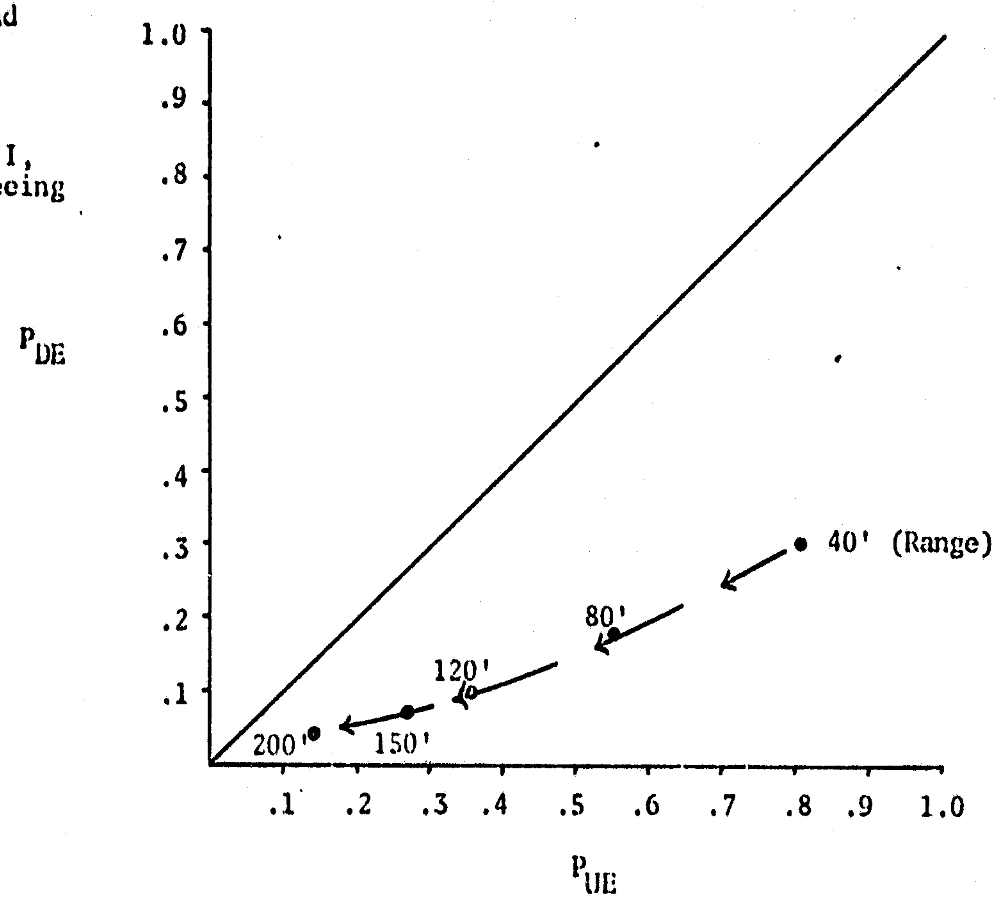


FIGURE 12. Summary Graph (P_{DE} vs P_{UE} as a Function of Range)

Round B--Low Impact Round

Scenario III, Suspect Fleeing on Foot



Scenario IV, Dispersal of a Crowd

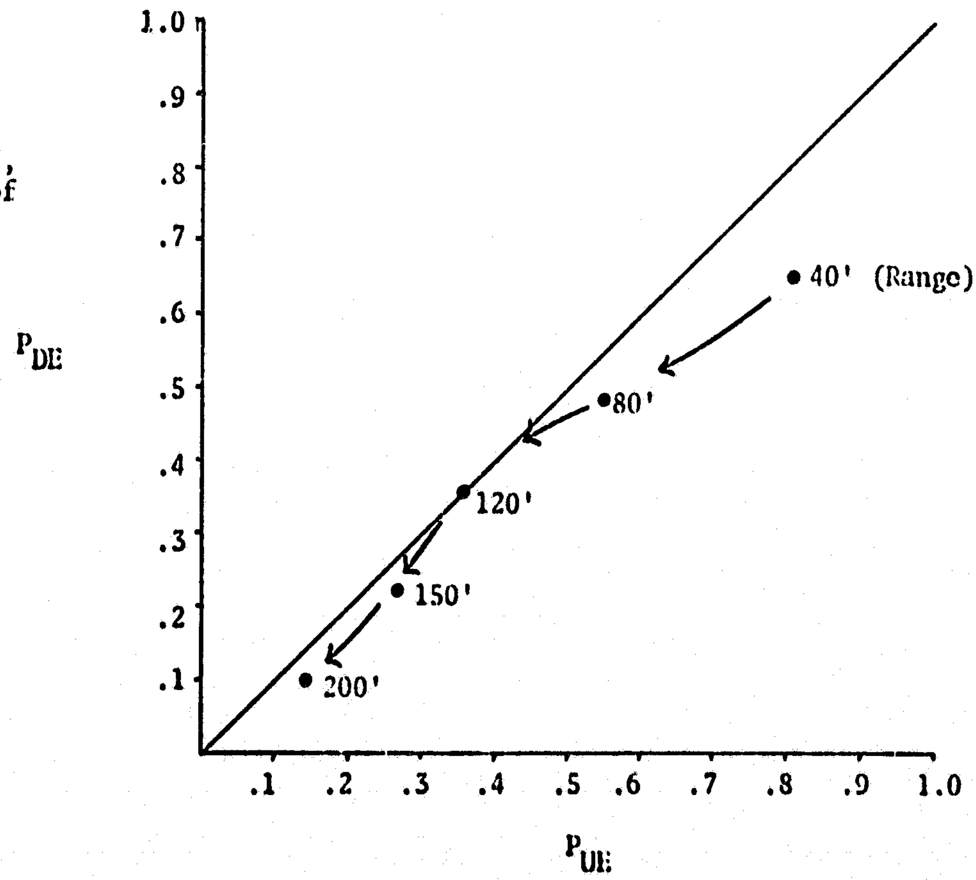
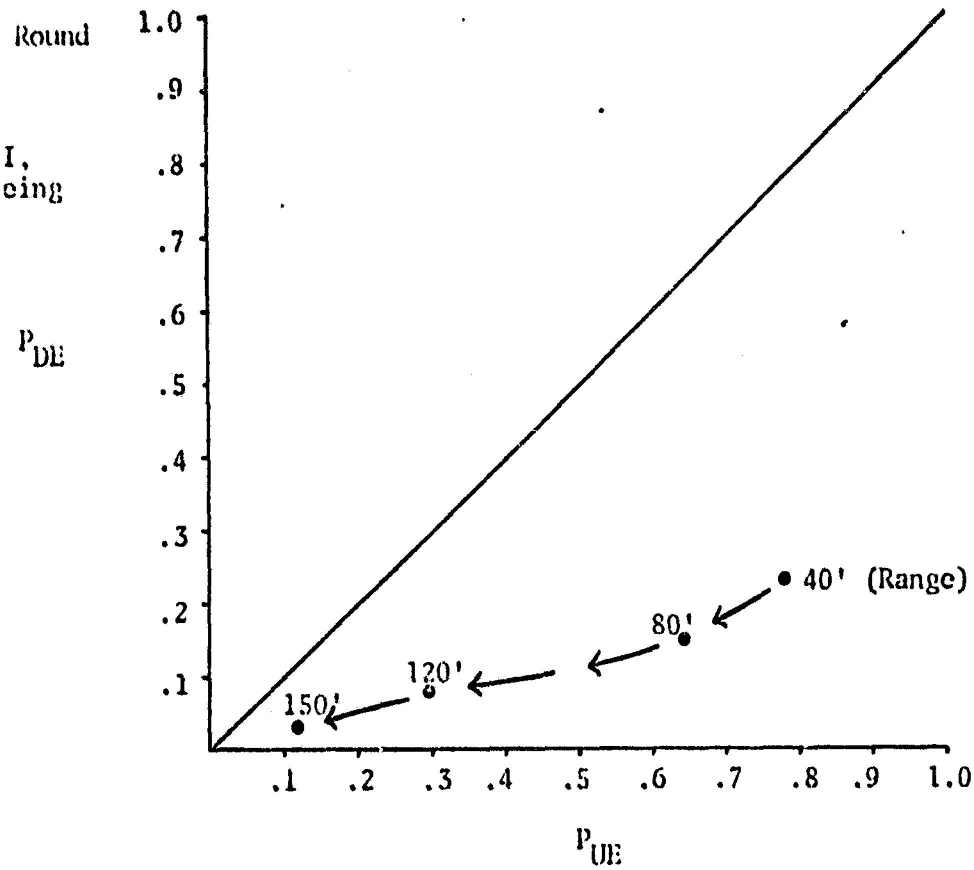


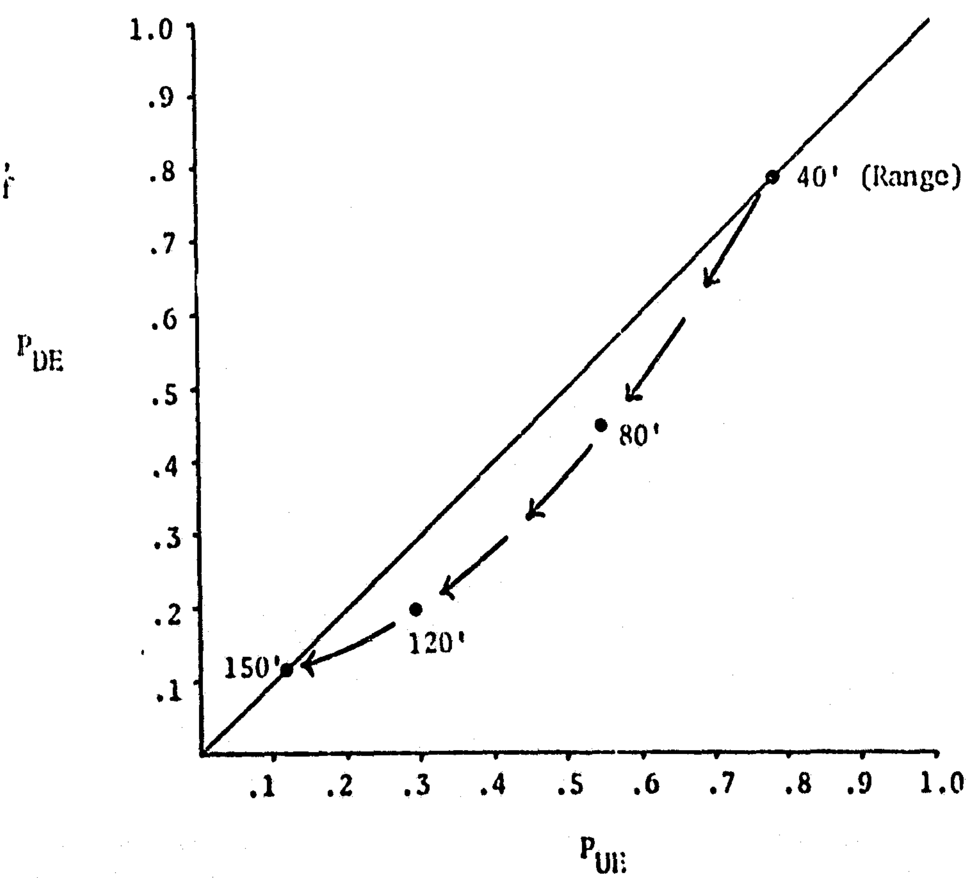
FIGURE 13. Summary Graph (P_{DE} vs P_{UE} as a Function of Range)

Round C--
Close Range Round

Scenario III,
Suspect Fleeing
on Foot



Scenario IV,
Dispersal of
a Crowd



In Scenario IV, Rounds B and C both approximate the diagonal line in the Summary Graphs, i.e., the expected P_{DE} and P_{UE} are roughly equal. Both of these rounds provide a "show of force" with probabilities of desirable effects greater than .4 for ranges up to approximately 90 to 110 feet. The poor performance of Round A in Scenario IV is partially explained by the likelihood that a shot on the head with this round will cause unconsciousness (an undesirable effect), whereas a shot on the head with Rounds B or C (because of their lower kinetic-energy impact) will probably not cause unconsciousness, but will have the generally desirable effect of inducing the individual to leave the scene.

It should be pointed out that in referring to the Summary Graphs and the Damage Profile Graphs simultaneously, the P_{DE} and P_{UE} figures on the two series of graphs do not mean the same thing. In the Damage Profile Graphs, the probabilities represent the probability of effects given a hit; in the Summary Graphs, the probabilities include the probability of a hit. Each shot of Round A at ranges under 80 feet delivers considerably more than 140 foot-pounds of kinetic energy. Impacts at even this energy level are almost certain to have an undesirable effect, so any reduction in the P_{UE} from the 1.0 level in the Summary Graphs is entirely due to hit probabilities.

III. OBSERVATIONS

In analyzing the Stun-Bag as a less lethal weapon the following observations have been made:

A. An impact by a Stun-Bag can cause damage to several organs, not all of which are directly under the point-of-impact. In particular the liver seems to be damaged by impacts on areas of the body remote from the physical location of the liver, and by both low- and high-energy impacts. The Medical Group discussed at length this "liver phenomenon."

B. Stun-Bag impacts may cause damage to internal organs without displaying any gross signature on the skin. This raises the problem of medical treatment for persons hit with nonfrangible projectiles of this type. Since there may be no obvious skin signature, medical diagnosis may be difficult.

C. In terms of accuracy, at 25 yards a proficient user of the .38 caliber is able to attain a standard error of less than six mils. However, the standard error for the Stun-Bag at 25 yards was about 19 mils, or approximately three times as great as the error of the .38 caliber. These figures are based on less than exhaustive testing, but are reliable to the extent that the Stun-Bag accuracy is much less than that of the .38 caliber.

D. One Stun-Bag round (Round A) provides "stopping power" sufficient to be effective against a suspect fleeing on foot, and two of the Stun-Bag rounds (Rounds B and C) provide a "show of force" sufficient to be effective in dispersing a crowd. However, the cost of obtaining either of these results may be a high probability of undesirable effect.

The above observations are based on limited data analysis. A more extensive testing program would be required before final judgments could be made.

IV. APPENDICES

APPENDIX A

SUPPORTING CALCULATIONS

I. Trajectory Calculations

The following numerical integration procedure was used to calculate normal trajectories of Stun-Bags (or other similar projectiles), given initial velocities and weights, and taking into account air resistance. The procedure computes range coordinates, $x(t_i)$ and $y(t_i)$, and velocity $v(t_i)$ at time t_i by numerically integrating the differential equations:

$$\ddot{x}(t_i) = -cv(t_i)\ K_D\ \dot{x}(t_i)$$

$$\ddot{y}(t_i) = -cv(t_i)\ K_D\ \dot{y}(t_i) - g$$

where: $c = \rho d^2/m$, d = diameter of projectile in feet

ρ = air density = 0.081 lb/ft^3

m = weight of projectile in pounds

$v(t_i)$ = velocity of projectile at time t_i in ft/sec

t_i = time elapsed from time zero in sec

$\dot{x}(t_i)$, $\dot{y}(t_i)$ = rates of change of horizontal and vertical distances with respect to time at time t_i in ft/sec

g = gravitational acceleration = 32.2 ft/sec^2

K_D = drag coefficient - This dimensionless constant may be input as data for use by the program or may be computed as a function of velocity by the program according to the following expression:

$$K_D = c_1 = c_2M + c_3M^2 + c_4M^3 + c_5M^4$$

where: the c's are constants and M is mach number defined as $v(t_i)/v_s$ (v_s is the velocity of sound and is taken as 1,120 ft/sec).

II. Summary Graph Calculations

Calculations supporting the Summary Graphs involve three stages: computation of hit probabilities; estimation of probabilities of desirable and undesirable effects as a function of kinetic energy; and combination of these two sets of probabilities. The data used include estimation of horizontal and vertical standard deviations of miss distance, use of the Test Shot Summary Tables, and estimation of presented areas of the head and the rest of the body for the average male human.

The error value used for the horizontal standard deviation, σ_h, is five mils; the value used for the vertical standard deviation, σ_v, is 19 mils. The areas (in square inches) presented by the head and the rest of the body are 46.5 and 795.2, respectively.

The formula used to combine these data into a probability of hit is:

$$P_{hit} = \frac{A_t}{A_t + 2\pi\sigma_h\sigma_v K^2},$$

where A_t is the presented area of the target, σ_h and σ_v are as defined above, and K is a range-dependent factor for converting mils into inches. (A mil in inches is one one-thousandth of the range in inches.) Now, if $A = 2\pi\sigma_h\sigma_v K^2$, then $A = 190\pi K^2 = 596.90K^2$. Computation of A is summarized in Table A-I below for various ranges of interest.

TABLE A-I

COMPUTATION OF $A = 2\pi\sigma_h\sigma_v K^2$

σ_h = 5 mils, σ_v = 19 mils

Range (ft)	K (inches/mil)	A (square inches)
40	0.48	137.53
80	0.96	550.10
120	1.44	1237.73
150	1.80	1933.96
200	2.40	3438.14

The ranges chosen in Table A-I represent distances at which kinetic energies for the Stun-Bag are estimated. From these kinetic energies and extrapolation from the Test Shot Summary Tables (Tables X and XI of the main text), estimates are made of P_{UE} and P_{DE} for Scenarios III and IV. (It should be noted here that extrapolations of this nature depend a good deal on subjective evaluation of the cause of damage in the animal test shots. Certain shots have been ignored because it was ascertained through review of high-speed movies taken during the test that these shots produced glancing blows and their èffects should be treated separately. Additionally, "clustering" of results is taken more seriously than averages.)

The support calculations for the Summary Graphs are displayed in Tables A-II through A-IV. Except for the combinations, the numbers appearing in these tables have been explained in the main text. They represent the probability of occurrence of some desirable or undesirable effect.

To explain the process of combinations, consider a column of probabilities of some effect, P_{UE}, P_{DE} (III), or P_{DE} (IV), for a given range/kinetic energy. Let P_{e_1} and P_{h_1} be the probability of effect and the probability of hit, respectively, for the head, and P_{e_2} and P_{h_2} be similar probabilities for the rest of the body. Then the formula for the combination of these probabilities into a total probability of some effect on the body as a whole is:

$$1-[(1-P_{e_1} P_{h_1})(1-P_{e_2} P_{h_2})].$$

TABLE A-II

SUMMARY GRAPH SUPPORT CALCULATIONS

(Super Long-Range Round)

Assumed: weight, .35 lb; horizontal error, 5 mils; vertical error, 19 mils

Range (ft)	Kinetic Energy (ft-lb)	Body Area	P_{UE}	P_{DE} III*	P_{DE} IV*	P_{hit}
40	196.4	Head	1.00	1.00	1.00	0.25
		Rest of Body	1.00	0.70	0.25	0.85
		Combination	0.89	0.70	0.41	
80	144.5	Head	1.00	1.00	0.00	0.08
		Rest of Body	1.00	0.50	0.40	0.59
		Combination	0.62	0.35	0.24	
120	103.6	Head	0.90	0.90	0.10	0.04
		Rest of Body	1.00	0.30	0.70	0.39
		Combination	0.41	0.15	0.28	
150	81.0	Head	0.75	0.70	0.60	0.02
		Rest of Body	0.90	0.25	0.70	0.29
		Combination	0.27	0.09	0.22	
200	53.3	Head	0.30	0.20	0.40	0.01
		Rest of Body	0.90	0.25	0.75	0.19
		Combination	0.17	0.05	0.15	

*Denotes number of LEAA Scenario

TABLE A-III

SUMMARY GRAPH SUPPORT CALCULATIONS

(Low Impact Round)

Assumed: weight, .35 lb; horizontal error, 5 mils; vertical error, 19 mils

Range (ft)	Kinetic Energy (ft-lb)	Body Area	P_{UE}	P_{DE} III*	P_{DE} IV*	P_{hit}
40	87.7	Head	0.75	0.50	0.50	0.25
		Rest of Body	0.90	0.25	0.70	0.85
		Combination	0.81	0.31	0.65	
80	60.0	Head	0.40	0.50	0.30	0.08
		Rest of Body	0.90	0.25	0.80	0.59
		Combination	0.55	0.18	0.48	
120	49.1	Head	0.25	0.10	0.20	0.04
		Rest of Body	0.90	0.25	0.90	0.39
		Combination	0.36	0.10	0.36	
150	35.7	Head	0.20	0.10	0.20	0.02
		Rest of Body	0.90	0.25	0.75	0.29
		Combination	0.27	0.07	0.22	
200	24.4	Head	0.00	0.00	0.10	0.01
		Rest of Body	0.75	0.20	0.50	0.19
		Combination	0.14	0.04	0.10	

*Denotes number of LEAA Scenario

TABLE A-IV

SUMMARY GRAPH SUPPORT CALCULATIONS

(Close Range Round)

Assumed: weight, .35 lb; horizontal error, 5 mils; vertical error, 19 mils

Range (ft)	Kinetic Energy (ft-lb)	Body Area	P_{UE}	P_{DE} III*	P_{DE} IV*	P_{hit}
40	48.1	Head	0.25	0.10	0.20	0.25
		Rest of Body	0.90	0.25	0.90	0.85
		Combination	0.78	0.23	0.78	
80	34.8	Head	0.20	0.10	0.20	0.08
		Rest of Body	0.90	0.25	0.75	0.59
		Combination	0.54	0.15	0.45	
120	24.4	Head	0.00	0.00	0.10	0.04
		Rest of Body	0.75	0.20	0.50	0.39
		Combination	0.29	0.08	0.20	
150	20.9	Head	0.00	0.00	0.00	0.02
		Rest of Body	0.40	0.10	0.40	0.29
		Combination	0.12	0.03	0.12	

*Denotes number of LEAA Scenario

APPENDIX B

MINUTES OF MEDICAL GROUP MEETINGS

This appendix includes the substance of the "raw" minutes of several meetings of the Medical Group of the Less Lethal Weapons Evaluation Panel.

Contained in the minutes are summary tables which include "EKG grades" and associated comments for a number of the test shots. It should be noted that these "EKG grades" were made prior to the formal establishment of EKG grading criteria; they do, however, represent the "feeling" that these would be realistic grades if the criteria had been established beforehand. In fact, as a result of the EKG's from which these "grades" were derived, it was decided to formally establish EKG grading criteria for two additional areas of heart damage, namely, conduction disturbance and myocardial injury. The rationale involved in these decisions will be found in the minutes of the meetings.

Additionally, for the sake of brevity, the following information, which was common to the minutes of all the Medical Group meetings, will be stated here and will not be repeated for each individual set of minutes.

I. Methodology

The methodology used to derive the effects estimates for these meetings is the same as that utilized in all previous Medical Group meetings, namely;

o The undesirable effect definition is reviewed. This definition is independent of the scenario and is stated as follows:

> Undesirable effect is that anatomical and/or functional effect which persists longer than 24 hours and prevents an individual from performing routine daily tasks and/or produces permanent impairment as defined by the American Medical Association (AMA) ratings.

o The desirable effect definition is reviewed. This definition is scenario-dependent and is stated in the minutes for the scenario(s) involved.

o Sequential color slides of a specific wound tract are shown to the group. The group reviews the damage grade level previously assigned to the various organs by the veterinary pathologist who performed the necropsies. Then, using increments of five percent, the group independently estimates the undesirable/desirable effects* for the wound and provides supporting rationale.

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*The estimated probability of desirable effects, as stated in the following tables, is based on the overall pain associated with the physiological damage sustained by the target as a result of one impact and should not be confused with the general nonphysiologically desirable effects estimates rendered by the Methods/Behavior Analysis Group (Appendix C). In other words, the P_{DE} estimates are based upon the Medical Group's estimate of the individual's inability to function rather than on a psychological determination that the individual is deterred by threat of pain.

After all estimates are made, the estimates are discussed by the entire group. Modifications to original estimates are permitted. Discussion continues until a consensus position is obtained, i.e., until the group feels reasonably comfortable with posted damage grade values, effects estimates and supporting rationale. This procedure is repeated for each wound.

II. Results

Results are shown in the appropriate tables. Note that the probabilities cited should be interpreted as follows: A .10 probability means that out of 100 people sustaining the impact, 10 will be expected to experience the effect of interest and 90 will not.

Comments pertinent to a particular meeting will be included in the extract of the minutes of that meeting.

A. Extract from Minutes of Medical Group Meeting, 5 April 1973

This meeting was mainly concerned with the consideration of the undesirable effects of Stun-Bag impacts on the head/skin (baboon targets) for all police-type scenarios. Table B-I presents the basic results obtained through the deliberations at this meeting.

B. Extract from Minutes of Medical Group Meeting, 18 May 1973

1. Undesirable Effects

Taking up where the 5 April 1973 meeting ended, the undesirable effects of Stun-Bag impacts on parts of the body other than the head (swine targets) were estimated (See Table B-II below). During review of the damage level grades, it was noted that significant damage to the liver resulted from both low- and high-energy impacts and, surprisingly, significant damage occurred when the impact point was remote from the liver. This "liver phenomenon" was first recognized by the veterinary pathologist when test velocities and resulting damage did not correlate. During this meeting, the "liver phenomenon" was discussed at length. It was hypothesized that bag contact angle (i.e., face-on, edge-on, etc.) and pressure wave formations (analogous to a shaped-charge effect) were constituent parameters of this phenomenon. No conclusive arguments were presented; however, the Medical Group agreed that the big difference in damage associated with a given energy level may have a significant bearing in the long-run on selection of the weapon.

2. Desirable Effects

The physiologically-based desirable effects for the Stun-Bag were estimated for the LEAA Scenario III, Suspect Fleeing on Foot. The desirable effect in this scenario is that physiological effect which will reduce the suspect's flight speed to a value which would permit a law enforcement officer to pursue, overtake, and apprehend the suspect within a reasonable distance (20 to 100 meters) or time (20 to 30 seconds). Voting members of the Medical Group rendered probability estimates of desirable effects which were based upon the pain associated with the physiological damage. The results of this estimation exercise are shown in Tables B-III and B-IV.

TABLE B-I

PROVISIONAL ESTIMATES OF PHYSIOLOGICALLY UNDESIRABLE EFFECTS, ALL SCENARIOS

Stun-Bag (Baboons)

Animal No.	Damage Grade Head	Damage Grade Skin	P_{UE}	Remarks
319	0	0	.80	Sore head but not badly hurt. A few sturdy characters would go to work.
323	0	0	0	No damage.
309	1	2	.20	Some swelling.
310	1	3	.20	Ditto.
301	0	2	0	No significant damage.
302	0	0	0	Ditto; damage level of skin changed from 1 to 0.
311	0	4	1.00	Massive fracture; facial injuries.
322	0	2	.20	20 percent would "goof off" (play sick). Damage level of skin changed from 3 to 2.
320	0	3	.50	--
312	1	4	.75	Some swelling in brain; some extraneous blood; search for more information at histopathology.
325	0	2	.10	Swelling of neck; basilar hemorrhage.
316	3	1	.75	Contracontusions; headache. Damage level of head changed from 2 to 3.
304	1	0	.10	--
303	2	0	.10	--
313	3	0	.50	Neck injury; will sue for whiplash.
314	3	3	1.00	Subdural hemorrhage; broad area of contusion; basal sub-arachnoid hemorrhage. Damage level to head changed from 2 to 3.

TABLE B-I (CONT)

Animal No.	Damage Grade Head	Damage Grade Skin	P_{UE}	Remarks
315	2	3	.50	Localized hemorrhage; histopathology necessary for confirmation.
321	0	0	0	Glancing blow; essentially a miss. Film will be reviewed very carefully.
324	0	0	0	No damage.
305	0	2	0	--
306	1	0	0	--
307	0	0	0	Damage grade at point of impact to the skin was not 2. Damage level to skin changed from 2 to 0.
308	1	2	.25	Skin lesion would be painful.
317	5	4	1.00	Gross damage.
318	2	2	.25	Subcutaneous edema. Damage level of head changed from 1 to 2.

TABLE B-II

PROVISIONAL ESTIMATES OF PHYSIOLOGICALLY UNDESIRABLE EFFECTS, ALL SCENARIOS

Stun-Bag (Swine)

Animal No.	Damage Grade Body Region	Skin	P_{UE}	Remarks
302	*Liver 4 Lung 2 Bone 3	2	.90	Damage grade to lung changed from 3 to 2. Fractured liver, fractured ribs, and blood clot. Patient would have a very sore belly.
306	*Liver 1 Other 2	0	.10	Damage grade to liver changed from 2 to 1 with reservation--check histopathology. Peritoneal bruise, slight blood clot. A small percentage would have pain.
305	*Liver 3	1	.50	Fractured liver; painful with swelling.
304	*Liver 4	1	1.00	Classical infarction pattern observed in other shots. Liver necrosis. Hemoperitoneum.
301	*Liver 3 Heart 5	0	1.00	Animal died in five minutes. Heart damage pre-empts liver damage.
303	*Liver 4	2	1.00	Liver necrosis.
309	*Kidney 4	3	.75	Not enough fracturing of the kidney for a 5. Damage grade to kidney changed from 5 to 4 because fracture did not penetrate to the pelvis. There would be blood in the urine and a painful lesion on the side but no visible evidence on surface of skin underneath.
307	*Kidney 0	1	0	No significant damage.
312	*Kidney 4	3	.75	Painful. Fractured liver.
311	*Kidney 0 Liver 5	1	1.00	Shot hit a little high. Call this a liver shot. Liver necrosis.

*Denotes target area

TABLE B-II (CONT)

Animal No.	Damage Grade Body Region	Skin	P_{UE}	Remarks
310	*Kidney 4	4	1.00	Multiple fractures in kidney. Stretched capsule on kidney is very painful.
308	*Kidney 0	4	.50	Skin damage only.
317**	Liver 4 Kidney 2 Lung 2	2	1.00	Animal was hit in thorax. Verify point of contact on film. Liver necrosis will disable. Other damage is insignificant.
314**	Liver 2 Lung 2 Bone 2 Heart 0/5***	2	1.00	Damage grade to liver changed from 3 to 2. EKG changes--immediate ventricular fibrillation.
316**	Liver 4 Lung 2 Heart 0	1	1.00	Hardly any would go to work. Liver and lung damage.
318**	Liver 0 Lung 2 Heart 0 Bone 2	3	1.00	Add damage grade 2 to bone. Fractured ribs. Patient would cough blood, and chest would really hurt.
315**	Lung 2 Heart 0/5*** Bone 2	5	1.00	Animal died. Death attributed to marked EKG changes.
313**	Liver 3 Lung 2 Heart 0/5***	4	1.00	Animal died immediately. EKG showed marked abnormalities. Ventricular fibrillation.
324	*Spleen 0 Other 2	0	.50	Pain and distress in belly. Subserosal hemorrhage of colon.
321	Liver 3 *Spleen 1	3	1.00	Hemoperitoneum. Liver necrosis.
320	*Spleen 0	2	0	No significant damage.

*Denotes target area
**Target area was the thorax.
***The second value for the heart represents the "EKG grade."

TABLE B-II (CONT)

Animal No.	Damage Grade Body Region	Skin	P_{UE}	Remarks
319	*Spleen 0 Liver 4	3	1.00	Liver damage.
322	*Spleen 2 Other 2	3	.50	Subserosal hemorrhage of colon. Tip of spleen damaged. Would have blood in stool.
323	*Spleen 0 Lung 2 Other 1	2	.75	Subserosal hemorrhage of colon. Pain in belly. Would be spitting a little blood.
325	Bone 0	2	.25	Thigh* shot. Minimal damage.

*Denotes target area

TABLE B-III

PROVISIONAL ESTIMATES OF PHYSIOLOGICALLY DESIRABLE EFFECTS, SUSPECT FLEEING ON FOOT, LEAA SCENARIO III

Stun-Bag (Baboon)

Animal No.	Damage Grade Head	Damage Grade Skin	P_{DE}	Remarks
319	0	0	.50	Would knock down temporarily. Good size hematoma.
323	0	0	0	No affirmative damage.
309	1	2	.10	No evidence of concussion. Contralateral lesion present does not suggest a concussion; contusion focus.
310	1	3	.50	Some would be knocked out. Scalp hemorrhage; head acceleration would cloud their sensorium.
301	0	2	0	Not much damage.
302	0	0	0	Not much damage.
311	0	4	1.00	Fractured bones, purple eye.
322	0	2	.10	Only a few would be disabled.
320	0	3	.10	Evidence of small contusion, some acceleration in brain.
312	1	4	.50	Subarachnoid hemorrhage.
325	0	2	0	Not much damage.
316	3	1	.75	This hit deformed the skull; contracontusion. Large force levels.
304	1	0	.10	Subarachnoid hemorrhage.
303	2	0	0	The group pondered over the vascularization, but concluded that it was not significant since all animals were bled out the same.
313	3	0	.50	No lesion in the brain. Significant lesion at the base of the neck.

TABLE B-III (CONT)

Animal No.	Damage Grade Head	Damage Grade Skin	P_{DE}	Remarks
314	3	3	1.00	Cerebral commotion; subarachnoid hemorrhage.
315	2	3	.90	Lesion on far side of impact; a little swelling.
321	0	0	0	Probably no test--check high-speed film.
324	0	0	0	No gross lesion.
305	2	0	0	No apparent damage.
306	1	0	0	Ditto.
307	0	0	0	No gross damage. Not much to go on for estimate of P_{DE}; animal may have struck chair.
308	1	2	.10	A small subarachnoid hemorrhage. Small lesion; enough to make you a little wary.
317	5	4	1.00	Gross damage.
318	2	2	.50	About 50 percent of the people would be knocked out.

TABLE B-IV

PROVISIONAL ESTIMATES OF PHYSIOLOGICALLY DESIRABLE EFFECTS, SUSPECT FLEEING ON FOOT, LEAA SCENARIO III

Stun-Bag (Swine)

Animal No.	Damage Grade: Body Region	Damage Grade: Skin	P_{DE}	Remarks
302	*Liver 4 Lung 2 Bone 3	2	.25	Rib broken, but not displaced; liver ruptured. Patient would be aware that he was in trouble.
306	*Liver 1 Other 2	0	0	Not much damage.
305	*Liver 3	1	0	Not much damage.
304	*Liver 4	1	.25	Similar to Animal No. 302.
301	*Liver 3 Heart 5	0	1.00	Ruptured heart. Would not go far.
303	*Liver 4	2	.25	Some pain in chest.
309	*Kidney 4	3	0	Not much swelling or damage. Enough pain in flank for P_{DE} of .10 or zero--consensus was zero.
307	*Kidney 0	1	0	No significant damage.
312	*Kidney 4	3	.10	--
311	*Kidney 0 Liver 5	1	.25	Stretching of pleural diaphragm.
310	*Kidney 4	4	.25	Will start bleeding very quickly. It takes a pretty good jar to do this amount of damage.
308	*Kidney 0	4	.10	Bruise from glancing blow.
317**	Liver 4 Kidney 2 Lung 2	2	.25	Subcapsular hematoma.

*Denotes target area
**Target area was the thorax.

TABLE B-IV (CONT)

Animal No.	Damage Grade Body Region	Skin	P_{UE}	Remarks
314**	Liver 2 Lung 2 Bone 2 Heart 0/5***	2	.75	Three fractured ribs without displacement. Animal died in minutes. EKG changes--immediate ventricular fibrillation.
316**	Liver 4 Lung 2 Heart 0	1	.10	A little damage.
318**	Liver 0 Lung 2 Heart 0 Bone 2	3	.50	Five broken ribs. Impaired circulation gives apparent loss of breath
315**	Lung 2 Heart 0/5*** Bone 2	5	.50	One broken rib. Very little physical damage to heart; however, immediate EKG changes appear significant enough to cause death more than ten minutes later--ventricular fibrillation.
313**	Liver 3 Lung 2 Heart 0/5***	4	1.00	EKG shows marked rhythm changes--severe enough to cause death.
324	*Spleen 0 Other 2	0	--	No significant damage.
321	Liver 3 *Spleen 1	3	.25	A pretty good impact based on liver damage. 25 percent would stop.
320	*Spleen 0	2	0	No significant damage.
319	*Spleen 0 Liver 4	3	.10	Slight liver damage.
322	*Spleen 2 Other 2	3	0	No significant damage.
323	*Spleen 0 Lung 2 Other 1	2	.10	Probably be some blood-spitting with this sort of lesion. Hemoptysis spitting of blood).

*Denotes target area
**Target area was the thorax.
***The second value for the heart represents the "EKG grade."

TABLE B-IV (CONT)

Animal No.	Damage Grade		P_{DE}	Remarks
	Body Region	Skin		
325	Bone 0	2	0	No significant damage (thigh* shot).

*Denotes target area

C. Extract from Minutes of Medical Group Meeting, 15 June 1973

The primary purpose of this meeting was to estimate the probable desirable effects (LEAA Scenario IV, Dispersal of a Crowd)* of Stun-Bag impacts based on test results (physiological damage) against baboons and swine (See Tables B-V and B-VI). However, the minutes of the Medical Group Meeting conducted on 18 May 1973 were reviewed. On Swine Shot Nos. 313, 314 and 315, the probability of desirable effects, P_{DE}, estimate had been reserved until EKG's could be analyzed. These EKG's were available at this meeting, analyzed, and the missing estimates of P_{DE} were rendered. In discussion during and following the review of the EKG's, it became apparent that dual criteria were needed to describe the heart damage. It was agreed that the original criteria be separated into physical and electrical damage. Rationale for this change was that when plotting the relation between damage level and kinetic energy for the vital organs there was a real danger of not knowing if the damage level to the heart that was plotted was due to physical or electrical damage. The new grading system for the heart is as follows.

GRADING SYSTEM FOR THE HEART

Damage Grades for Physical Damage

1. Epicardial and/or myocardial hemorrhages 2 cm or less in diameter.

2. Epicardial and/or myocardial hemorrhages greater than 2 cm in diameter.

3. Myocardial necrosis less than 2 cm in diameter.

4. Myocardial necrosis greater than 2 cm in diameter.

5. Rupture of the heart.

Damage Grades for Electrical Damage**

1. No electrocardiographic conduction or rhythm changes.

2. Transient conduction or rhythm changes lasting 10 seconds or less.

3. Electrocardiographic conduction or rhythm changes lasting longer than 10 seconds, but less than 1 minute.

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*The desirable effect in this scenario is to motivate the crowd to move of its own accord.

**This EKG category was renamed Conduction Disturbance, and grade levels were changed from 1-5 to 0-4, respectively, at a subsequent group meeting (See minutes, 20 July 1973).

TABLE B-V

PROVISIONAL ESTIMATES OF PHYSIOLOGICALLY DESIRABLE EFFECTS, DISPERSAL OF A CROWD, LEAA SCENARIO IV

Stun-Bag (Baboons)

Animal No.	Damage Grade Head	Damage Grade Skin	P_{DE}	Remarks
319	0	0	.50	Would see stars; no brain damage. Hardest thing to evaluate is concussive effect. Cannot assume unconsciousness. Even if he was, he would not be out five minutes.
323	0	0	0	No evidence (physical damage) that he would move.
309	1	2	.10	Bridging vein was torn loose--not a true contracontusion; subarachnoid hemorrhage.
310	1	3	.50	Scalp movement (stretched); subarachnoid dilatation.
301	0	2	0	Not much of a blow.
302	0	0	0	Ditto.
311	0	4	.90	Fracture of eye arch. 10% may not be able to leave.
322	0	2	.10	Not much damage--skin lesion.
320	0	3	.25	Area of hemorrhage is greater than for Animal No. 322.
312	1	4	.90	Inverted eye effect. Subarachnoid hemorrhage.
325	0	2	0	No damage.
316	3	1	.25	Subarachnoid hemorrhage; head was accelerated; some swelling at 24 hours; contracontusion. Check photo micrographs. Reserve final P_{DE} until histopathology.
304	1	0	0	Low-energy impact. No significant damage.
303	2	0	.10	A little bit of hemorrhage in scalp. A solid hit.

TABLE B-V (CONT)

Animal No.	Damage Grade Head	Skin	P_{DE}	Remarks
313	3	0	.75	Scalp damage; bruise at base of head. Possible unconsciousness.
314	3	3	.90	Subdural hemorrhage; cerebral commotion. 10% probably unable to leave.
315	2	3	.75	Subarachnoid hemorrhage; lesion on ventral surface.
321	0	0	0	Brush burn at most.
324	0	0	.10	Bridging vein stretched, produces minor lesion. Slight headache.
305	2	0	0	No significant damage.
306	1	0	0	Ditto.
307	0	0	0	Animal hit back of chair.
308	1	2	.10	Small lesion.
317	5	4	0	Black eye--optical lesion; headache; fractured skull (would not be able to leave, unconscious).
318	2	2	.50	Subdural hemorrhage--onset of headache. Sliding of brain tears bridging veins.

TABLE B-VI

PROVISIONAL ESTIMATES OF PHYSIOLOGICALLY DESIRABLE EFFECTS, DISPERSAL OF A CROWD, LEAA SCENARIO IV

Stun-Bag (Swine)

Animal No.	Damage Grade Body Region	Skin	P_{DE}	Remarks
302	*Liver 4 Lung 2 Bone 3	2	.75	Vascular lesion, immediate hemorrhage. Hard blow to belly; peritoneum pain.
306	*Liver 1 Other 2	0	.10	Minimal physical damage.
305	*Liver 3	1	.50	Tearing of capsule really hurts. Pain is excruciating in belly.
304	*Liver 4	1	.75	Extensive fracturing and subsequent necrosis of liver.
301	*Liver 3 Heart 5	0	0	Rupture left ventrical.
303	*Liver 4	2	.75	Liver lesion--like on Animal No. 304; 25% would not be able to leave.
309	*Kidney 4	3	.75	Blow over kidney. Rabbit punch--would hurt like the devil.
307	*Kidney 0	1	0	No lesion--no effect.
312	*Kidney 4	3	.50	Perirenal hemorrhage.
311	*Kidney 0 Liver 5	1	.75	Liver lesion.
310	*Kidney 4	4	.90	Fair bruise over kidney. Pretty good blow. A few unable to leave--a few would resist.
308	*Kidney 0	4	.90	Hit hard enough to make them move.
317**	Lung 2 Liver 4 Kidney 2	2	.75	Liver damage; little bit of kidney damage.

*Denotes target area
**Target area was the thorax.

TABLE B-VI (CONT)

Animal No.	Damage Grade Body Region	Skin	P_{DE}	Remarks
314**	Liver 2 Lung 2 Bone 2 Heart 0/5***	2	0	Fractured ribs; probable cardiac death.
316**	Liver 4 Lung 2 Heart 0	1	.90	Lung and liver damage.
318**	Liver 0 Lung 2 Heart 0 Bone 2	3	.90	Chest wall, rib and lung injured. Hurt, but not disabled.
315**	Lung 2 Heart 0/5*** Bone 2	5	0	Died of electrical conduction disturbance. Time until death exceeds five-minute criterion.
313**	Liver 3 Lung 2 Heart 0/5***	4	0	Immediate death.
324	*Spleen 0 Other 2	0	--	--
321	Liver 3 *Spleen 1	3	.75	Good bruise, hemorrhage. Severe pain in belly. 25% would either endure pain or be unable to leave.
320	*Spleen 0	2	.10	Stings a little.
319	*Spleen 0 Liver 4	3	.75	Liver tear--blood in belly.
322	*Spleen 2 Other 2	3	.50	Fair bruise (subcutaneous); serosal hemorrhage.
323	*Spleen 0 Lung 2 Other 1	2	.50	Subpleural; fair bruise (subcutaneous).
325	Bone 0	2	.25	Thigh* shot. Bruised skin.

*Denotes target area
**Target area was the thorax.
***The second value for the heart represents the "EKG grade."

Damage Grades for Electrical Damage* (Cont)

4. Electrocardiographic conduction or rhythm changes lasting longer than 1 minute, but survival for 24 hours.

5. Electrocardiographic changes indicating fibrillation, other marked rhythm changes, or electrical conduction changes severe enough to cause death.

D. Extract of Minutes of Medical Group Meeting, 20 July 1973

The primary purpose of this meeting was to produce an effective coordination with the Los Angeles County Less Lethal Weapons Task Force. Data banks of the probability of effects estimates were reviewed and generated for applicable scenario/less lethal weapon combinations which have been previously addressed by the Medical Group under the objectives of the overall program. This entailed, essentially, an exercise of the estimation procedure which has been utilized in previous meetings. Supplemental agenda items included a discussion of chemical agent effects and a demonstration firing of some less lethal weaponry.

The chairman outlined briefly the primary purpose of the meeting. Dr. T. T. Noguchi (Los Angeles County Coroner) was asked to participate in the evaluation procedure. It was decided to estimate probability of desirable effects for the Stun-Bag when employed against the Fleeing Suspect in Army Scenario I. Effects for the Stun-Bag in this scenario had not been previously addressed by the Medical Group, but Army Scenario I (Fleeing Suspect) and LEAA Scenario III (Suspect Fleeing on Foot) are quite similar, differing very slightly only in range of engagement and time to apprehend.

The evaluation procedure was reviewed for the benefit of Dr. Noguchi and new Medical Group member, Dr. W. F. Renner, Cardiologist. While going through the estimation of desirable effects, it was decided to estimate the undesirable effects at the same time. Although the undesirable effect estimates had already been rendered in a previous meeting, the process was repeated to give Dr. Noguchi and Dr. Renner a better feel for estimating probability effects for the same wound tract under different definitions.

The estimates of the desirable and undesirable effects for the Fleeing Suspect in Army Scenario I are summarized in Table B-VII. The swine series of tests was selected for evaluation for this meeting because it provided a variety of tissue and organ damage.

As a result of earlier tests and the subsequent Medical Group evaluation of test data, the electrical conduction of the heart was established as a crucial evaluation parameter. The importance of the electrical activity of the heart is such as to warrant monitoring on every animal which will be used in future tests. To strengthen the evaluation team, Dr. W. F. Renner was

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*This EKG category was renamed Conduction Disturbance, and grade levels were changed from 1-5 to 0-4, respectively, at a subsequent group meeting (See minutes, 20 July 1973).

TABLE B-VII

PROVISIONAL ESTIMATES OF PHYSIOLOGICALLY DESIRABLE/ UNDESIRABLE EFFECTS, FLEEING SUSPECT, ARMY SCENARIO I

Stun-Bag (Swine)

Animal No.	Damage Grade Body Region	Damage Grade Skin	P_{DE}	P_{UE}	Remarks
302	*Liver 4 Lung 2 Bone 3	2	.75	1.00	Belly ache, blood in urine.
306	*Liver 1 Other 2	0	--	--	No slides.
305	*Liver 3	1	.10	.20	Pain, sore belly with some people; gross lesion, not of too much significance in 24 hours.
304	*Liver 4	1	.75	1.00	Arterial infarction. Similar to Animal No. 302. Hemoperitoneum causes significant belly pain.
301	*Liver 3 Heart 5	0	--	--	No slides.
303	*Liver 4	2	--	--	No slides.
309	*Kidney 4	3	.25	.90	Blood in urine, back pain.
307	*Kidney 0	1	0	0	No physical evidence of damage.
312	*Kidney 4	3	.25	.90	Similar to Animal No. 309.
311	*Kidney 0 Liver 5	1	.75	1.00	Liver necrosis.
310	*Kidney 4	4	.25	1.00	Liver damage appears to be in center of organ where blood vessels are located.
308	*Kidney 0	4	--	--	No slides.
317**	Liver 4 Kidney 2 Lung 2	2	.75	1.00	Some kidney damage.

*Denotes target area
**Target area was the thorax.

TABLE B-VII (CONT)

Animal No.	Damage Grade Body Region	Skin	P_{DE}	P_{UE}	Remarks
314**	Liver 2 Lung 2 Bone 2 Heart 0	2	1.00	1.00	Dr. Noguchi stated that research in Japan shows heart has tendency to stop if hit just prior to p-wave.
316**	Liver 4 Lung 2 Heart 0	1	.10	.50	Heart is like a pendulum; liver is fragile but relatively fixed.
318**	Liver 0 Lung 2 Heart 0 Bone 2	3	.50	1.00	Internal organ damage, with dull ache. Damage to rib and surrounding area would produce sharp pain.
315**	Lung 2 Heart 0 Bone 2	5	1.00	1.00	EKG--ventricular fibrillation.
313**	Liver 3 Lung 2 Heart 0	4	1.00	1.00	EKG--ventricular fibrillation.
324	*Spleen 0 Other 2	0	.10	.10	Spleen is pretty flexible; pain only.
321	Liver 3 *Spleen 1	3	.75	1.00	--
320	*Spleen 0	2	0	0	--
319	*Spleen 0 Liver 4	3	.50	1.00	--
322	*Spleen 2 Other 2	3	0	.10	--
323	*Spleen 0 Lung 2 Other 1	2	0	.20	Hemoptysis.
325	Bone 0	2	0	.10	Thigh* shot.

*Denotes target area
**Target area was the thorax.

retained to read, interpret, and document EKG traces on all future animal tests. His input is expected to enlighten others knowledgeable of, but not proficient in, cardiology and add credence to supporting rationale which is aligned with probability estimates. At a previous meeting, Dr. Renner was asked to further develop the criteria for assessing heart EKG abnormalities resulting from blunt-trauma-producing impacts. It seems appropriate that the results of his endeavor be preserved here in these meeting minutes, since the work was presented by Dr. Renner at this meeting. The dissertation (given below) was prompted by a review of High-Q Sphere (superball) impacts. The proposed grading system was approved by the Medical Group as presented. The new grading system for electrical damage to the heart, and supporting rationale, is as follows.

GRADING OF ELECTROCARDIOGRAPHIC EVIDENCE OF HEART ABNORMALITY FROM NONPENETRATING PRECORDIAL CHEST INJURIES

There are two general categories of EKG evidence of cardiac abnormality which may be expected to develop from nonpenetrating precordial chest injuries:

1. Rhythm and Conduction Disturbances:

   It is well documented that nonpenetrating precordial chest injuries in experimental animals may cause rhythm and conduction disturbances, specifically A. V. block, intraventricular conduction disturbances and extrasystoles.

   Page two of the minutes of the Medical Group Meeting of 15 June 1973 contains criteria for grading rhythm and conduction changes under the heading "Damage Grades for Electrical Damage."

2. EKG Changes Characteristic of Acute Myocardial Injury:

   In man, chest trauma is often followed by ST elevation and later pointed inversion of T. Such changes generally are not accompanied by any changes of the QRS complex and are probably due to direct mechanical injury of the subepicardial muscle layers. In other cases deep Q-waves are present in addition to the ST and T changes. In such cases transmural myocardial necrosis or infarction due to traumatic injury of a coronary artery may be found. Infarction may also be found without thrombosis of a coronary artery. If the impact occurs in systole, the myocardium may become injured by stretching at its thinnest point. Less severe injuries may show only depression of ST and T.

A review of the EKG's recorded to date in the nonlethal project suggests a correlation of EKG changes of the above types with the velocity of the superball and the findings of physical damage at necropsy.

It seems, therefore, that EKG changes of myocardial injury should be studied as well as rhythm and conduction disturbances. Although it would be desirable to integrate the EKG evidence of acute myocardial injury with the EKG evidence of rhythm or conduction disturbances into a single grading system which would reflect increasing degrees of damage, this does not seem feasible because of inherent differences in the two categories of evidence. It is suggested, therefore, that the grading system already approved be retained for grading rhythm and conduction disturbances and be known as Category CD (conduction disturbances) and that a Category MI (myocardial injury) be adopted to grade degrees of myocardial injury with subdivisions as follows:

0 - No EKG changes warranting a diagnosis of acute myocardial injury.

1 - Transient ST depression or elevation suggesting relatively small and reversible myocardial injury.

2 - Protracted ST depression followed by T-wave inversion suggesting more severe subendocardial injury possibly accompanied by subendocardial necrosis.

3 - Protracted ST elevation followed by T-wave inversion suggesting acute subeipcardial injury and probably some degree of subendocardial necrosis.

4 - Development of abnormal Q-waves with ST changes suggesting transmural necrosis or infarction, i.e., major heart damage which might well cause death and would be expected to leave permanent residual damage.

As an example of how this grading system would work, an animal with no evidence of physical damage at necropsy but with a transient burst of extrasystoles of less than 10 seconds and protracted ST depression accompanied by T-wave inversion would be graded as:

- PD (physical damage) - 0
- CD (conduction disturbance) - 2
- MI (myocardial injury) - 3.

It is to be noted that for all three categories, i.e., PD, CD, and MI, 0 indicates no evidence of damage. Furthermore, 5 indicates the maximum damage likely to cause death for Category PD, whereas 4 indicates the maximum damage likely to cause death for Category CD or Category MI.

The meeting was adjourned after some concluding comments from Dr. Noguchi and Mr. B. Katz (Los Angeles County Assistant District Attorney) regarding the evaluation procedure. From their comments it is inferred that Dr. Noguchi was both interested and pleased to have been afforded the opportunity to participate in a typical evaluation of a damage mechanism. Mr. Katz, on the other hand, had observed very highly motivated people in various situations and would like to see evaluation of actual situations where less lethal weapons are being or have been used.

APPENDIX C

MINUTES OF METHODS GROUP* MEETING, 11 MAY 1973

I. General

The attendees keyed on an agenda as follows:

A. Review of work of the Methods Group to date

B. Discussion of best sources of information for the evaluation of human response to noxious stimuli

C. Establishment of an emotional state(s) for evaluations

D. Information required by the Group in the conduct of evaluation

E. Evaluation of the "bean bag" (Stun-Bag)

F. Necessary adjustments to the procedure to evaluate irritants

G. Re-examination of the concept of a pig-deterrent experiment

H. Critical review of the Group's evaluation of the "superball."

Topics A through E inclusive were discussed. Time did not permit any formal discussion of topics F through H as this would have extended the meeting past the scheduled adjournment time.

II. Detail

The Chairman reviewed the work of the Methods Group to date. Prior to this meeting the Methods Group had assembled three times. The first of these meetings was held on 9 March 1972. This was primarily an organizational meeting. Topics of discussion included scenario development, candidate less lethal weapons, and the concept of desirable and undesirable effects produced when these types of weapons are employed in scenarios of current interest. In the second meeting (17 August 1973) there was an attempt to formulate rationale and estimates of probability of desirable effects. Some estimates were rendered but only after some very, very trying discussion. The third meeting was held on 29 December 1973. The estimates of desirable effects came somewhat easier during this meeting. The nature of the weapon addressed, viz., the .38 caliber revolver, may have had a significant bearing on the facility with which the damage mechanism estimates were rendered. Also, some probability estimates for the effect of threat and display of the weapon were made at this meeting.

The Group was then asked to comment from their experiences on the best sources of information for the evaluation of human response to noxious stimuli.

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*Now called Behavior Analysis Group

CONTINUED

1 OF 2

It was stated that we are dealing in the realm of an inexact science. We have a problem in choosing the correct word or esoteric term to describe the response, e.g., rainfall on crowd--an observation which we know to cause a crowd to disperse; characteristics of the mob member, i.e., "pain may become pleasurable at times." Under an emotional situation, an individual may be analogous with a black box. You put something in....(noxious stimulus) and you get something out (human response), but you are not certain what has gone on inside the box.

It was further emphasized that data on human behavior is generally, almost universally, taken under very controlled situations--like in a laboratory. Subjects are ordinarily college student volunteers who have been screened as "normal." (Normal behavior is a situation like the shaking of a hand.) One member of the Group believes laboratory data for well-motivated vs nonmotivated individuals is available. These involve controlled experiments (actually controlled observations); e.g.,

- o girl watching gorillas
- o man watching birds.

The difficulty, of course, would be to correlate the observed response of normal college student volunteers to various stimuli in a laboratory with the response of an angry, emotional and irrational individual whom we are trying to motivate by the employment of these less lethal weapons. Although it was reported that some work has been done under real-life situations (candid observation and recording), the results of this effort have not been published.

The Group was confronted with establishing an emotional state(s) for evaluations. It should be noted that the Group has not addressed this question to date even though it has been asked in prior meetings. There appears perhaps a missing link in the form of a correct term or terms to use when asking the question or, in fact, in answering it. Also, it appears to be the "sin of psychology" that we can say much but convey little.

Perhaps the stumbling block in establishing these emotional levels is that we do not know the emotional background or make-up of the crowd. The individual is more easily defined in terms of make-up. Constituent parameters in establishing the emotional states would be pain and suggestability (hypnosis), yet a great many people cannot be hypnotized. The element of surprise would certainly be important. One of the Group members suggested that another dimension was needed, such as blood flow or no blood flow.

It is very difficult or almost impossible to measure emotional states. The available literature is quite minimal. It was suggested that, for the purpose of our analysis, a number scale of 1-3 or 1-5 be established. Such a scale might be as follows:

Emotional Level of "Mob Member"	Type of Mob Associated with Emotional State
1	Picket line for wage increase
2	Crossing picket line
3	Street gangs
4	Political extremists
5	Lynch mobs.

The "trick" in making the weapon effectiveness estimates will be the ability of the panel to analogize the levels above in the scenarios.

The question was asked if you could infer emotional levels of the crowd from viewing motion picture films taken of riots. In short, this was felt to be difficult because film editing involves sensationalism. Highly-motivated and highly-intelligent are good terms to describe riot members. It has been observed that riot members cannot be prodded like cattle.

Discussion continued among the Group members as to the information that is required in the conduct of evaluations. The Dispersal of a Crowd Scenario was cited as an example wherein some information is known, but more definition is needed in certain areas, e.g.,

- o A large crowd is assembled for a civil disobedience.
- o The group members have an act planned.
- o The group has formal leadership.
- o The group is gathered over a social issue.
- o What is the emotional state of the crowd? (e.g., define before police arrive)

o Can we talk about the crowd in terms of distance?

It was suggested that we apply these added definitions to a specific, clear-cut crowd, such as a group involved in a rent strike, wherein there is a grievance which may be justified (trash removal, elevator does not work, etc.). An emotional intensity level of 1 or 2 might be characteristic of this crowd.

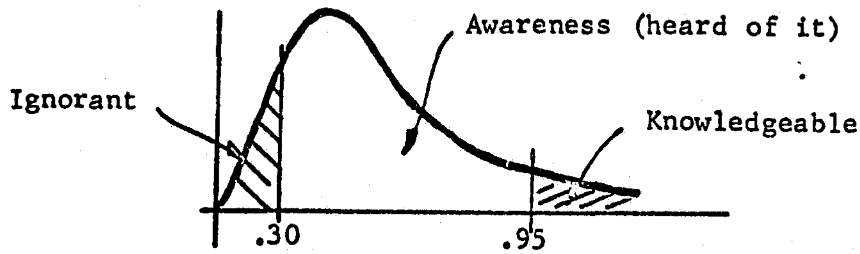
Emotional Level of Crowd	Description
0	Bored I. accidental presence II. disinterested III. annoyed
1	Calm
2	
3	
4	
5	Frenzied, furious, enraged

It was noted that the emotional state is a source of motivation but not the only one. Along these lines, we had a classical presentation of the relation between motivations and emotional state of crowds. This was outlined briefly as follows:

	Emotional State				
			Crowd Outburst		
Motivation	Pre-Mobilization	Mobilization	Passive	Active	Post-Hostility
A	*				
B					
C					
D					

*Data for filling in the entries for the table above are fragmented.

Using the rent strike as an example of the Dispersal of a Crowd Scenario, the Group rendered some estimates of effects given that the Stun-Bag was employed against the demonstrators in a confrontation. In this scenario we assumed the crowd to be middle-aged, with children, and they had gathered at city hall with the purpose of settling their grievance relating to the rent strike. The subtle implication in this scenario is that when the police arrive, the crowd knows that they "mean business." Also, the weapon which will be used has a signature. It was hypothesized that the approximate distribution of consumer wisdom of the weapon's attributes would be as follows:



An order would be given for the crowd to leave. The crowd's reponse is:

A. Some go home

B. Some remain to deal with the order

- o Some will be screaming at the police
- o Some will be very quiet
- o Some will talk it over with each other
- o Some will be angry under these conditions.

In general, that fraction of the crowd which remains will be moderately to markedly angry and shouting at the police. The emotional level may be as high as 3.

The Group was asked," Of the people who do get hit with the Stun-Bag, how many would leave?" Percentage estimates were as follows:

90, 75, 75, 68, 75, 50.

Rounding to the nearest 10 percent, the average percentage of the people that are hit and leave is 70.

The question was then asked, "What happens to the people who observe other people being hit? i.e., of those who perceive the physiological threat, how many leave the area?" Percentage estimates were as follows:

75, 85, 50, 20, 75, 75.

Rounding to the nearest 10 percent, the average percentage of people who leave the area upon seeing other people hit is 60.

The Group was asked to comment on their percentage estimates for the case where there was visible physical disruption--say a knockdown--or a severe physical change, such as getting a crushed rib. Some of the members increased their estimate by 10 percent; others more. It was finally agreed that virtually 100 percent of the people would leave if it were apparent that the police "mean business."

Desirable effects percentage estimates for the rent strike confrontation situation are summarized in Table C-I below.

TABLE C-I

SUMMARY OF PROBABLE DESIRABLE EFFECTS FOR STUN-BAG IN RENT STRIKE CONFRONTATION, WHERE P_{DE} = PROBABILITY OF DESIRED EFFECT (CROWD DISPERSES AND LEAVES SCENE WITHIN FIVE MINUTES)

Crowd Members	P_{DE}
Observing hit	.60
Hit	.70
Hit or observing hit resulting in severe physical change	1.00

The Group then examined a variation of the "Crowd Dispersal" Scenario in which the emotional level would be 3-4. A Vietnam protest gathering was proposed. The typical participant was envisioned to be a college student activist. As a whole, the group would be active and "ready." When told to leave, hardly anyone would go. Spurious groups might go off for more protesting; they may gather a few blocks away for rock-throwing. Participants here are extremely susceptible to crowd influence, i.e., they will act as the crowd would like them to act. Under the conditions of a hard-core element, maybe only two to three percent will leave, because these few people never get caught up in the emotion of the crowd.

Of the people who stay and get hit with the Stun-Bag, it was estimated that on the average 10 percent would leave the area. This estimate is a rounded-off figure to the nearest 10 percent of the following individual estimates:

10, 10, 5, 25, 25, 10.

For the people who observe a low level of damage to persons being hit, it was agreed that a very small percentage (less than five percent) of these people would leave. The rationale was that there would be no reason to leave if the guy who gets hit does not leave. Individual estimates for this case were:

0, 1, 5, 0, 5, 0.

For the case of individuals observing others being hit at high velocity--sufficient for a knockdown--the estimates were considerably higher for probability of leaving the area. Individual percentage estimates were:

15, 50, 50, 70, 40, 25.

Averaging and rounding to the nearest 10 percent yields 40 percent.

Desirable effects percentage estimates for the Vietnam protest gathering situation are summarized in Table C-II below.

TABLE C-II

SUMMARY OF PROBABLE DESIRABLE EFFECTS FOR STUN-BAG IN VIETNAM PROTEST GATHERING (DISPERSAL OF A CROWD, SCENARIO IV)

Crowd Members	P_{DE}
Observing hit	<.05
Hit	.10
Hit or observing hit resulting in severe physical change	.40

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END