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JAVELIN: A CASE STUDY IN MODEL-TEST-MODEL

by

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The goal of this thesis is to (1) examine the suitability of proposed scenarios for comparing the existing antiarmor system, Dragon versus the proposed system, Javelin; (2) compare the weapon systems according to approved measures of effectiveness (MOE) and, (3) identify potential additional test conditions which may cause significant changes in the MOE.

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JAVELIN: A CASE STUDY IN MODEL-TEST-MODEL

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I. INTRODUCTION

A. THESIS OBJECTIVE

The acquisition of new weapon systems is a long and expensive process. Test and Evaluation is a critical and costly step in that process. [Ref. 1, Ref. 2] Model-Test-Model is a relatively new concept being promoted as an operations research technique by which DoD can conduct more efficient and effective test and evaluation of proposed weapon systems as well as improve the validity of existing modeling tools or identify needed improvements. [Ref. 3, Ref. 4]

Model-Test-Model (MTM) consists of three phases. The first phase examines the proposed experimental design of the test in order to identify possible efficiencies in and effectiveness improvements of that design. [Ref. 3] To date only limited pre-test modeling of proposed or new weapon systems have been conducted prior to actual testing. This limited pre-test modeling included an Air Defense weapon system and an Armor weapon system, but never to the level of fidelity of Infantry weapon systems. [Ref. 5, Ref. 6] Additionally, even though some pre-test modeling has been done, none of the pre-test modeling results have been conducted in time to impact on the actual experimental design. As such, a chasm exists between the theoretical impact of MTM and empirical proof that existing modeling tools have the capability to accomplish these aims.

This thesis explores the suitability of pre-test MTM concepts for an infantry weapon system. Secondly this thesis investigates the possible impact pre-test modeling would have on the experimental design of the operational test of U.S. Army's current Medium Antitank Weapon system, Dragon versus a proposed replacement - Javelin. The test is scheduled in 1993 at Fort Hunter-Liggett, California. In order to address these objectives, this research applies MTM concepts using Test and Experimentation Command (TEXCOM) developed scenarios. Janus(A), the Army's principal combined arms, interactive, high resolution model is the tool used to generate research data. [Ref. 7] The data for the two weapon systems are evaluated according to three critical Measures of Effectiveness (MOE) which are based on Critical Operational Issues and Criteria (COIC) of the test. [Ref. 8]

B. ISSUES

In regards to the suitability of MTM concepts the specific issue addressed in this research is whether or not the representations of Infantry actions in Janus(A) are a realistic portrayal of corresponding actual Infantry actions. This issue will be addressed primarily through a literature search and discussion of applicable Infantry tactics and their corresponding representation in Janus(A). In regards to the efficiency and effectiveness of the experimental design, specific issues to be addressed include:

(1) whether or not the proposed scenarios are plausible and facilitate examination of the differences between the competing weapon systems, and

(2) identification of additional issues which could impact on the efficiency/effectiveness of the test design and employment of the weapon system.

C. BACKGROUND ON INFANTRY ANTIARMOR SYSTEMS

From the late 1960's the Army developed the Light Antitank Weapon (LAW), Medium Antitank Weapon (MAW) and Heavy Antitank Weapon (HAW) doctrine for infantry forces to combat enemy armored vehicles and weapon systems. The LAW is a short-range, light- weight weapon that a soldier carries in addition to his primary or assigned weapon. The LAW evolved from the M-72, a 66 milli-meter rocket with an approximate 200 meter range to the current AT-4 which has a larger 84 millimeter high explosive projectile and a greater 300 meter range. [Ref. 9]

Figure 1 Law Gunner in Action

The HAW is a heavy or crew-served weapon system. Its nomenclature is the TOW II (Tube-Launched, Optically-Tracked, Wire Command Link Guided) missile. Although the TOW II can be ground-mounted, it is usually vehicle mounted. In mechanized units the TOW II is mounted on the Bradley Fighting Vehicle and the Improved TOW Vehicle. It is mounted on the High Mobility Multipurpose Wheeled Vehicle (HMMWV) in light infantry units and Cobra Attack Helicopters in aviation units. It has a range of 3750 meters and a thermal night sight. [Ref. 9] The TOW II warhead has been modified to defeat reactive armor.

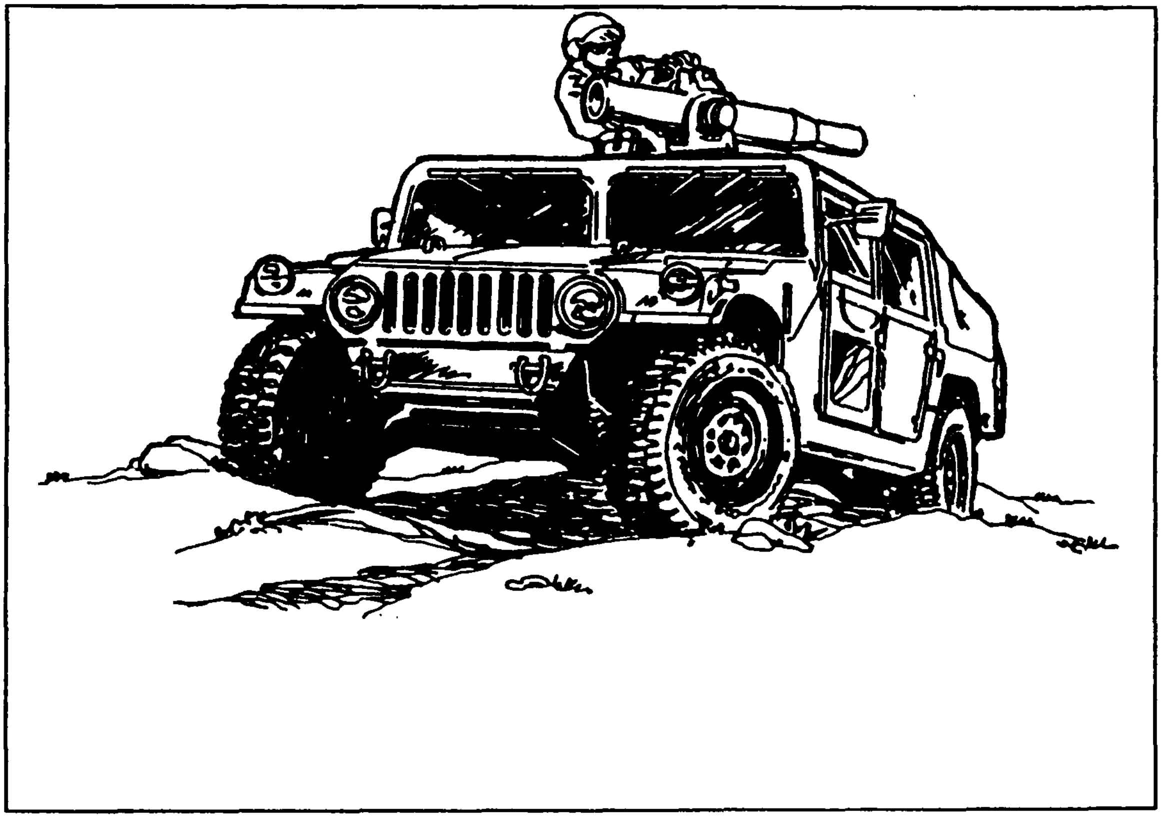


Figure 2 TOW Mounted on HMMWV

The current MAW is the Dragon. It is man-carried and is the primary antiarmor weapon system at platoon and company level. The Dragon's guidance system is similar to the TOW in that it is optically sighted, command-link wire-guided. It has a 1000 meter range and a thermal night sight. [Ref. 9]

Presently the Dragon gunner is required to guide a relatively slow-moving missile to the target. The range of most enemy tank main gun and heavy machine gun is 1500 - 1800 meters. Therefore, the Dragon gunner remains exposed for up to 11 seconds within the enemy's engagement range. This assumes the Dragon gunner fires at maximum engagement range. Even using proper flank and rear shot tactics, the gunner is still at risk. Also, improved armor has degraded the weapon's lethality. Given the deficiencies of limited range, gunner vulnerabilities, and eroded lethality, changes in tactics have not been able to sufficiently address the mission need. [Ref. 11]

Figure 3 Dragon Gunner Sighting Target

Javelin is under development to address the cited deficiencies. The Advanced Antitank Weapon System - Medium (AAWS-M) or the Javelin is designed to have an extended range of up to 2200 meters. Javelin is designated as a fire and forget weapon system which permits a gunner to acquire a target, fire on the target and immediately resume a covered and concealed position. The Javelin's guidance system is based on an infrared imagery seeker. The Javelin's missile when launched travels more than two times faster than the Dragon. Because the Javelin has a top-attack mode as well as a direct line of sight capability its inherent lethality is increased. Theoretically, a top-attack mode permits the missile to penetrate a thinner more vulnerable top than the better protected sides and front glacias.

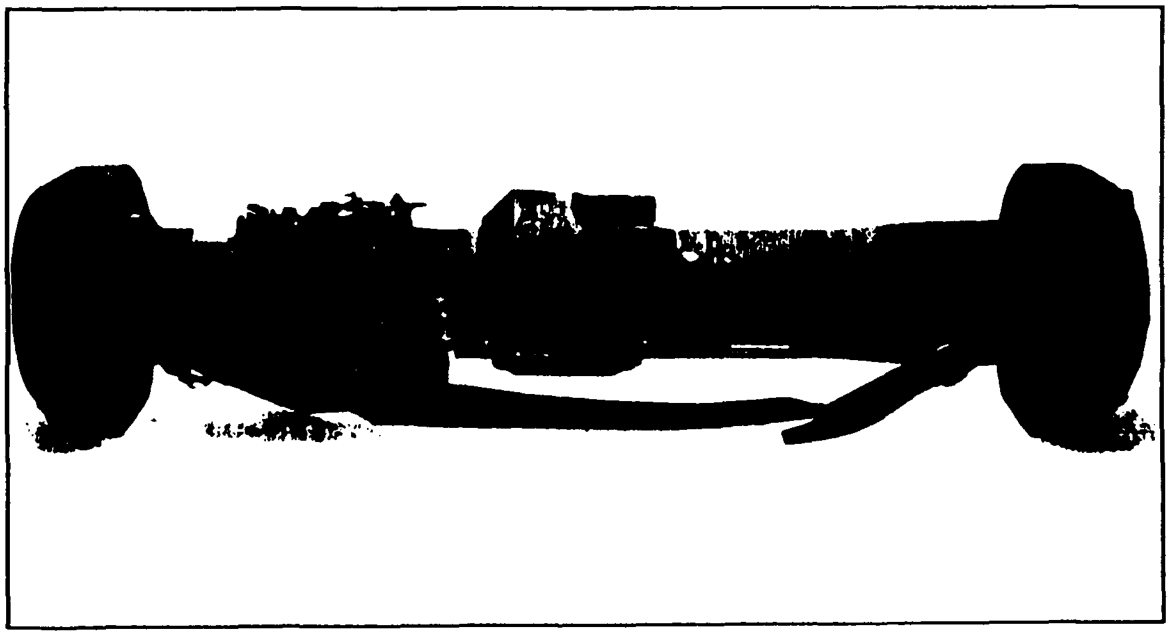


Figure 4 JAVELIN

II. MODEL-TEST-MODEL CONCEPT

A. MODEL-TEST-MODEL PHASES

Although Department of Defense policy for applying modeling and simulation in support of Operational Test and Evaluation has been in existence since 1989, MTM as presently applied is a relatively new concept. The MTM concept applies modeling directly in support of the operational test and evaluation process. This concept envisions the synergistic interaction of testing and modeling in order to positively impact both operational testing and the combined arms modeling process.

Mr. Hollis, Deputy Under Secretary of Army for Operations Research, approved and directed that additional MTM concepts be incorporated into Army Test and Evaluation Policy in 1991. [Ref. 3, Ref. 4] Since then DOD has also approved MTM. [Ref. 14, Ref. 15] MTM has three distinct phases. The first phase is pre-test modeling which simulates proposed test scenarios. The objective of pre-test modeling is to develop an efficient and effective experimental design. Pre-test modeling iteratively refines and adjusts the test design in order to balance test objectives with test costs.

The second phase is the test phase. While testing is conducted, modelers observe trials and data collection methods. Particular attention is given to definition of each data collection step in order to insure test data corresponds to model data.

The post test modeling phase focuses on examining the degree of association between model and test results. Normally this examination entails fixing selective parameters while statistically evaluating the association of repetitive modeling trials with corresponding test trials. This phase can also be used to extend test results beyond the tested scenarios and conditions. The rationale behind extending test results is to gain insight into the utility of the proposed weapon system where active testing costs may be prohibitive or testing constrained by safety or environmental consideration. One caution, however, is the further the extension or extrapolation is from the calibration points the less credible the model results may become.

The M1A2 tank and the Line of Sight Forward Heavy (LOSF-H), an air defense artillery system, have been partially evaluated under the MTM Concept. Both the LOSF-H and M1A2 were considered in a post-test evaluation. Pre-test modeling on the M1A2 was done with notional scenarios and MOE's. [Ref. 5, Ref. 6]

This MTM thesis research on the Javelin is unique for many reasons. It represents the first infantry system in the test and evaluation process to be explored using MTM. Secondly, this research represents the first time actual scenarios, terrain and measures of effectiveness will be used in the pre-test modeling of the operational test. Finally, this thesis represents the first time pre-test modeling will be conducted in time to impact on the actual test design.

B. DESCRIPTION OF JANUS(A)

The simulation used to conduct the pretest model is Janus(A). Janus is named for the Roman god who was the guardian of portals and the patron of beginnings and endings. Janus(A) is an interactive, two-sided, closed, stochastic, combined arms simulation. Interactive refers to decision making during the simulation or man-in-the-loop. Two-sided refers to two opposing forces. Closed means that opposing force distributions information is limited. Stochastic refers to the problematic way results such as direct fire engagements are determined. Combined arms means the principal focus is on combined arms forces and maneuver. Janus(A) also models weather, visibility, chemical environment, mines and any other combat variables. Terrain is depicted with contour lines, vegetation, roads, waters and urban areas. Theoretically terrain is represented by cells which correspond to Defense Mapping Agency elevation, vegetation, and cultural feature description. Graphic symbols represent one or more systems and each system has one or more weapons. For example the symbol for an infantryman may represent a nine man squad where each infantryman carries an M-16 rifle and a light antitank weapon. Combat between systems in the Janus simulation is initiated based on a standard Army detection algorithm for weapon system sensor capabilities. In addition to limitations imposed by sensor system capability, detections occur only if physical line of sight exists between the sensor and the target. If a system has line of sight, can range the target, has ammunition, and is not in hold-fire status, then the system fires the most appropriate weapon system at the target. Appendix A shows a photograph of a

Janus(A) display. The simulation resolves engagements by comparing random number draws to a probability of hit and kill database. Postprocessing files allow extensive data collection on the detection and engagement process. [Ref. 12]

III. SCENARIOS/MEASURES OF EFFECTIVENESS

Essential to any research on the suitability of MTM concepts for Infantry Weapon Systems is development of realistic scenarios which employ those weapons. TEXCOM - developed scenarios for the Initial Operational Test (IOT) of the Javelin provide the basis of the scenarios evaluated in this research. The scenarios examined in the model and the scenarios scheduled for conduct during the test correspond. The scenarios vary tactically and fall into offensive and defensive operations. Modeled scenarios include hasty defense, deliberate defense, deliberate attack and movement to contact/hasty attack (MTC). Conditions in these scenarios are systematically varied. Conditions include day operations with and without Mission Oriented Protective Posture (MOPP) equipment. Because Javelin has a long wave Infrared Sight, differences in the sensor between day and night conditions in the model are minimal. Further, night parameter data on Dragon/Javelin was not available for modeling given the time constraints of this thesis.

MOPP conditions vary for each scenario. Hence MOPP levels are factored into the Janus(A) modeling process. MOPP refers to the protective overgarments to include boots, gloves and mask that soldiers wear in a Nuclear, Biological or Chemical (NBC) contaminated area. A higher MOPP level reduces soldier effectiveness and increases reaction time. In MOPP4 soldiers wear protective clothing as well as a mask for a simulated NBC environment. For this research, the

MOPP level for the hasty defense in this analysis is MOPP4. The other three scenarios were modeled in MOPP0. The deliberate defense, deliberate attack and MTC scenarios were modeled under daylight conditions.

Modeled force sizes correspond with projected force sizes for the operational test. For the scenarios modeled this was platoon size blue forces and company size red forces for the hasty and deliberate defenses. For the deliberate attack and MTC, company size blue forces and platoon size red forces were modeled. It is also important to note the blue platoons and companies modeled are light or dismounted infantry. A blue platoon consists of 30 soldiers organized in three squads. Each platoon possesses two Dragon/Javelin Antitank weapons (MAW), two M-60 machine guns, six Squad Assault Weapons or light machine guns, 12 M-203 grenade launchers, and eight M-16 rifles. Each rifleman also carries 2 AT-4's. Each blue company is made up of three platoons. The blue force sizes and Dragon/Javelin complements are displayed in Table 1.

TABLE 1

BLUE FORCE SIZE				
	HASTY DEF MOPP4	DELIBERATE DEFENSE	DELIBERATE ATTACK	MOVEMENT TO CONTACT
BLUE SOLDIERS	30	30	90	90
MAW SYSTEMS	2	2	6	6

The red force company possess three T-72 tanks and eight BMP mechanized infantry fighting vehicles for a total of 11 vehicles. Red force platoons possess two T72's and two BMP's. The red force sizes are displayed in Table 2.

TABLE 2

RED FORCE SIZE				
	HASTY DEF MOPP4	DELIBERATE DEFENSE	DELIBERATE ATTACK	MOVEMENT TO CONTACT
RED VEHICLES	11	11	4	4

The MOE's considered are derived from the TEXCOM Critical Operational Issues and Criteria (COIC) selected for the Initial Operation Test which will occur in September 1993 at Fort Hunter-Liggett, California.

They are as follows:

- *Engagement Range*
- *average engagement range in meters*
- *Lethality*
- *# kills/# shots fired*
- *Survivability*
- *# friendly soldiers surviving/*
  # friendly soldiers starting

The MOE's above were selected for a number of reasons. First, they are directly addressed in COIC. They are quantifiable and easily derived from Janus(A) post-processing files. Other MOE's included in the COIC but not included in this research have less to do with the weapon system and more to do with the gunner. Examples include performance by soldiers with selected fitness scores or suitability criteria concerning manpower and personal integration (MANPRINT). These issues/MOE's cannot be described adequately in Janus at this time and if included would cloud weapon versus weapon comparison.

Another condition examined within the context of this thesis is basic load. This is not a condition that is addressed in the TEXCOM MOE or measures of performance, but may impact on COIC's such as Lethality and Survivability. Basic load is the number of rounds available per weapon system for a given scenario. Basic load varies according to mission as well as preparation time. For an offensive operation a Dragon/Javelin gunner will carry the weapon sight/launch unit and one round and the assistant gunner will carry a spare round. In the defensive operations, preparation time for a hasty defense is less than 24 hours. The unit may be limited to the rounds available in the platoon or what is in the company trains which may range from three to five. In the deliberate defense with 24-72 hours to prepare the company has time to resupply rounds from the battalion trains and up the basic load to six. [Ref. 16] See Table 3.

TABLE 3

BASIC LOAD				
	HASTY DEF MOPP4/ INC BL	DELIBERATE DEFENSE	DELIBERATE ATTACK	MOVEMENT TO CONTACT
BASIC LOAD	3/5	6	2	2

Preparation time impacts on other differences in hasty and deliberate defenses. Soldiers in a deliberate defense may have more or better obstacle plans as well as better prepared fighting positions which offer greater survivability. The differences between a deliberate attack and a MTC have to do with amount of intelligence known about the enemy's location and disposition. In a deliberate attack a unit knows the enemy's disposition and location and therefore can plan and execute protected routes to the enemy's location. In a MTC a unit is trying to find the enemy to make contact and destroy him. The chosen scenarios and conditions offer a broad cross-section of missions for the system to be tested. Imbedding the system into unit level operations will produce more relevant data for analysis.

IV. DISCUSSION OF SUITABILITY OF JANUS(A) REPRESENTATION

Janus(A) is similar to operational testing for direct fire engagements. Janus(A) uses line-of-sight algorithms while tests use lasers attached to the weapon. In both simulation and reality the firing system must have an unobstructed line-of-sight to the target to register a hit. In Janus(A), Infantry soldiers are represented as standing upright when they are moving. In reality soldiers crawl or move in crouched positions as well as upright. The inability of Janus(A) to model various individual soldier movements is overshadowed by the level of resolution in its terrain modeling. At present the finest degree for terrain resolution is 12.5 meter grids or squares. In Janus(A), soldiers in defensive positions can be in full or partial defilade. If a soldier is in full defilade he and his weapon cannot detect targets or fire at them. Real fighting positions fully prepared provide cover, concealment and overhead protection. Therefore a soldier with an antitank weapon could actually fire from a full defilade position. Janus(A) can be run interactively or non-interactively. For this research Janus(A) scenarios were allowed to run non-interactively. This means systems did not deviate from their original preplanned route of advance or direction of attack. A more realistic approach might be a man-in—the- loop so that the battle can be fought by reactive or thinking opponents. The reason the simulated battles were not fought interactively was to vary as few parameters as possible. Therefore the data generated for the MOE's was primarily weapon dependent and not man-in-the-loop dependent. Secondly, the stopping criteria for either side was reaching their march objective. A designated level of casualties sustained is another stopping criteria that may have more reasonably modeled reality. The march objective stopping criteria was selected because it was consistent and could be repeated for analytical purposes. It also generated a larger data population which gives more robustness to the analysis. Kills given hits in Janus(A) are binary in nature. Once a hit is generated it is selected as a casualty or suppression. Categorical kills for vehicles such as catastrophic, mobility and weapon system may represent reality more closely, but are not available in Janus(A). As previously mentioned Janus(A) does not allow systems to fire from a full defilade position. The system can be changed interactively from full to partial defilade so the system can fire. This artificiality may cause a slight degradation in survivability in the model not found in the test. These modeling issues need to be addressed to close the gap between simulation and reality but the important issue of survivablility is one of detection and accurate probability of hit/probability of kill (ph/pk). It is important to note that the actual ph/pk's for all weapon systems used as input are not included to keep the thesis unclassified. The detection algorithm in Janus(A) has been validated in other studies. The ph/pk's are generated by analysis done at TRADOC Analysis Command at Monterey and will be refined with input from other Army agencies and as further testing is completed.

V. EFFICIENCY AND EFFECTIVENESS OF THE EXPERIMENTAL DESIGN

A. METHODOLOGY

In order to examine whether or not the proposed scenarios are plausible and facilitate examining the differences between the competing weapon systems, five Janus(A) runs were conducted for each weapon system for all scenarios under the varied conditions. Although only five runs were made, the analysis represents from 30-60 total data points for each MOE. Means of these data points represent each of the five runs.

The basic analytical objective is to determine if the proposed scenarios revealed a statistical difference between the two weapon systems given the same scenarios.

A number of analytical tools were used to evaluate data resulting from this research. The first analytical tool used is notched box and whisper plots. Box plots provide useful information about location, dispersion and skewness. A notch is added to each box corresponding to a confidence interval around the median, while the width of the box is proportional to the square root of the number of observations in the data set. [Ref. 18, Ref. 19] Pair wise comparisons are made between the weapon systems by examining whether the notches overlap. The next tool used is One Way Analysis of Variance (ANOVA). This technique assumes normality, a common variance and independent samples. The hypothesis testing for each MOE varies according to scenario.

In each case the hypothesis tested were:

$$H_o : M_1 = M_2$$

$$H_a : M_1 \neq M_2$$

Where:

M_1 = mean of Dragon for each MOE

M_2 = mean of Javelin for each MOE

Next Bartletts test is used to test for common variance between the Dragon and Javelin. See Appendix B.

Finally the Kruskal-Wallis One Way Analysis by Ranks is used. This nonparametric technique is chosen because it makes no assumptions concerning shape and location parameters and thus provides robustness to analytical analysis performed.

B. RESULTS

1. Hasty Defense in MOPP4.

- Average Engagement Range: Analysis of notched box plots for the hasty defense in MOPP4 indicates the range for the Javelin is more than double the Dragon's range. The Javelin's median for average engagement range is approximately 1970 meters while the Dragon's median is approximately 960 meters. Little deviation exists from the median for both weapon systems. This is reasonable because both weapon systems have optimal fields of fire and will fire close to their maximum engagement ranges. The ANOVA and KW values support differences in the weapon systems to a five percent level of significance. See Figure 5 and Table 4.

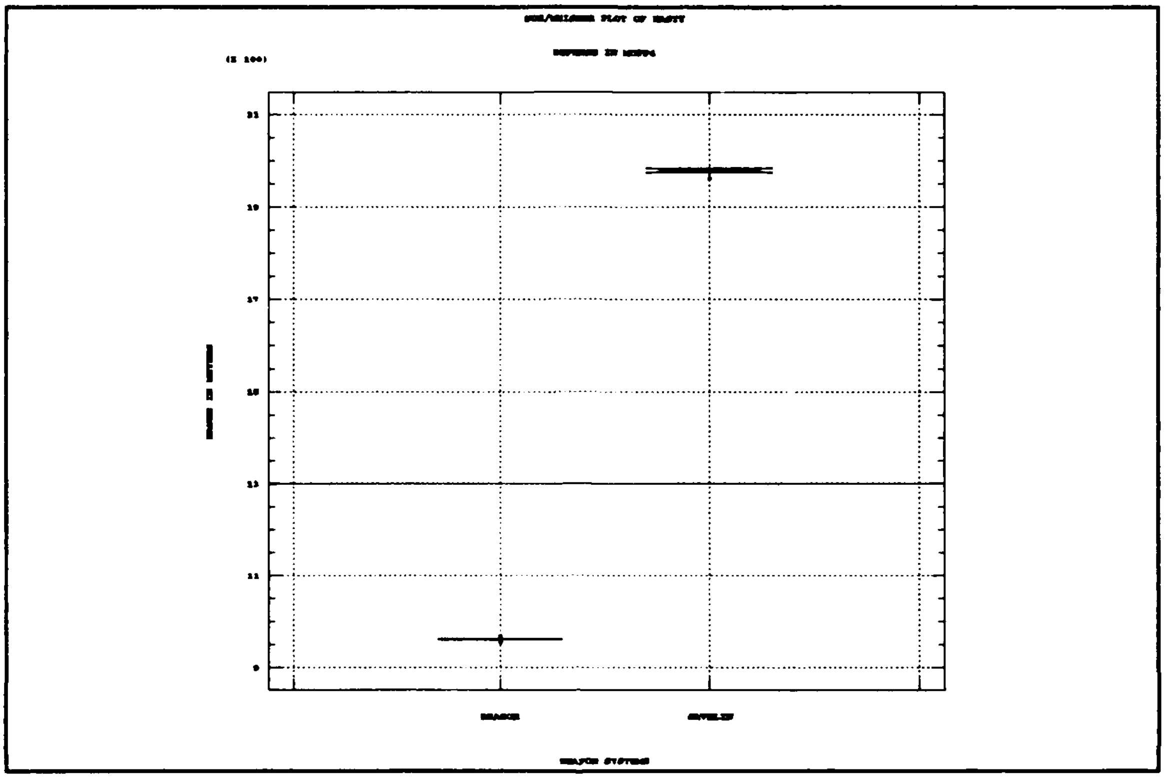


Figure 5

- Lethality: Lethality remains under 35% for the Dragon while the Javelin ranges from 80– 100% with the median near 100%. What appears to be an outlier for the Dragon is a valid data point representing six engagements. The lethality of 49% is slightly higher than the median but within the Dragon's ph/pk. The ANOVA and KW tests support rejection of the null hypothesis of equal means/means of rank. See Figure 6 and Table 4.

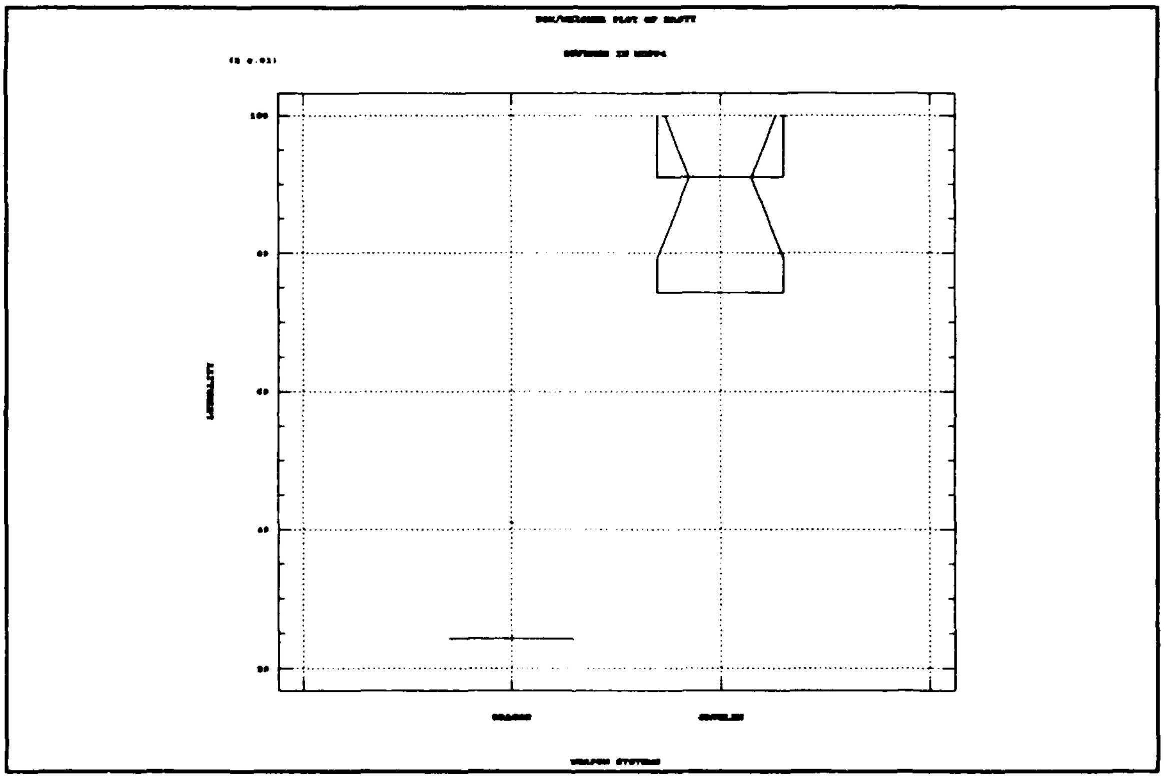


Figure 6

- Survivability: There is no significant difference between the weapon systems in survivability. The Dragon's median is approximately 93% while the Javelin's median is around 90% with an extremely wide confidence interval. ANOVA and KW results show no differences in the weapon systems. See Figure 7 and Table 4.

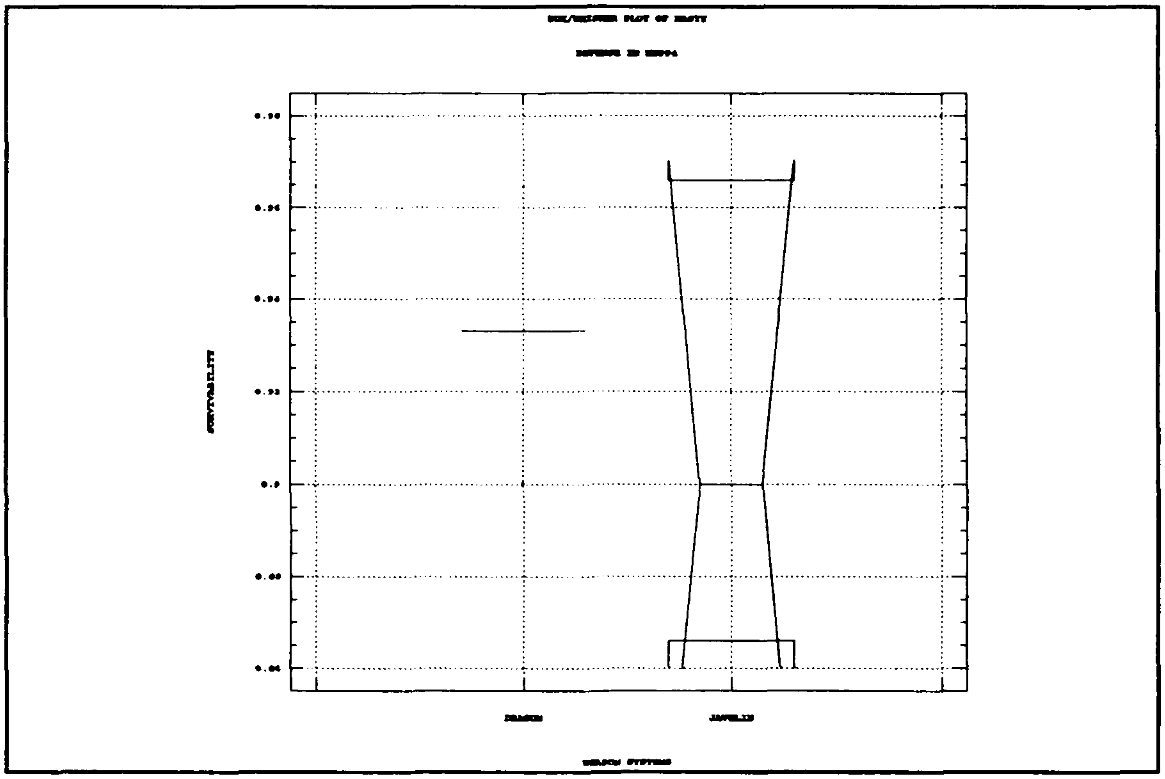


Figure 7

TABLE 4 ANOVA/KW VALUES FOR HASTY DEFENSE IN MOPP4

	ANOVA		KW	
	Test Statistic	P-Value	Test Statistic	P-Value
Range	46076.1	.0000	6.859	.0088
Lethality	115.193	.0000	7.500	.0062
Survivability	.334	.5852	.1895	.6633

2. Deliberate Defense.

- Average Engagement Range: As occurred for Hasty Defense in MOPP4 the medians of average engagement range are statistically different between the weapon systems in deliberate defense. The Dragon's median is 950 meters and the Javelin's is just under 2000 meters. ANOVA and KW analysis support differences between the weapons. See Figure 8 and Table 5.

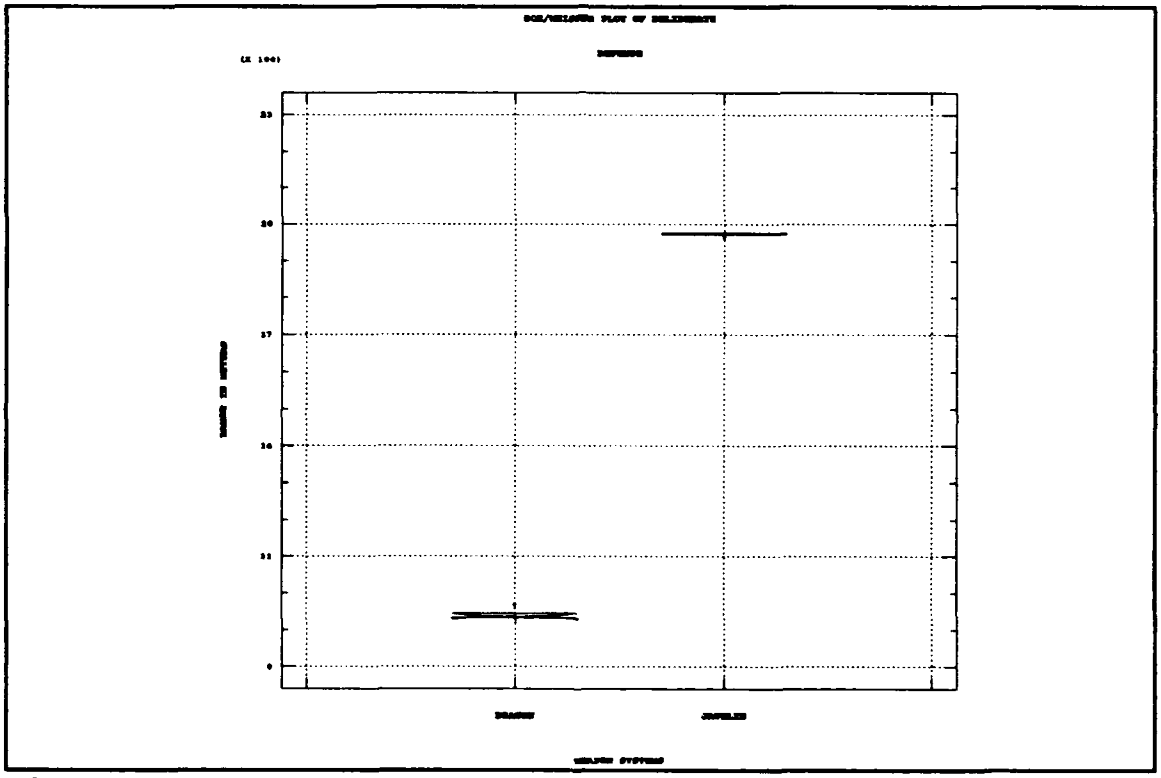


Figure 8

- Lethality: Median for the Dragon's lethality is approximately 50% while the Javelin is over 95%. ANOVA and KW results support differences between the Dragon and Javelin to a five percent level of significance. For this scenario there appears to be an outlier for the Javelin below the median. Due to the randomness of the simulation fewer first round hits were scored on that run but it remains a valid data point. See Figure 9 and Table 5.

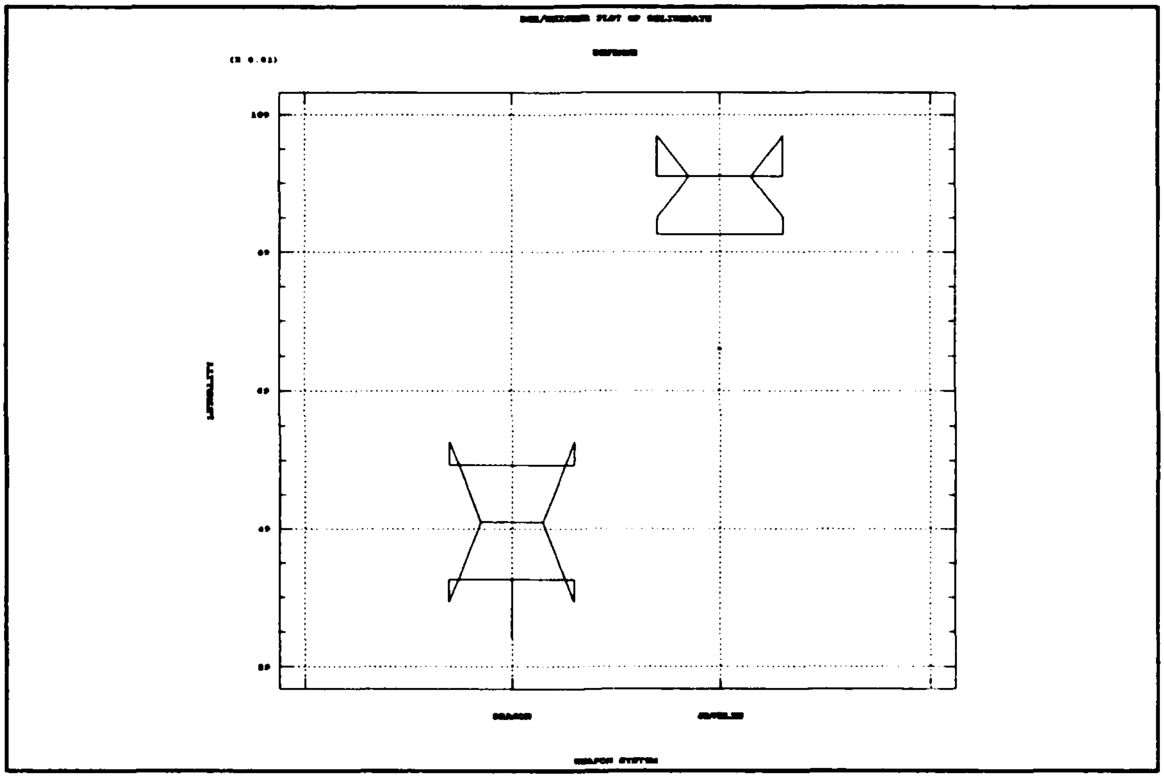


Figure 9

- Survivability: Median for the Dragon is around 93% while the median for the Javelin is 100%. The confidence intervals do not overlap thus showing differences in the medians for the weapons. ANOVA and KW values support the alternative hypothesis that the means/means of rank are not equal. The survivability is a constant 100% for the Javelin because the blue force possessed enough rounds to destroy all enemy vehicles before they were able to kill any blue soldiers. See Figure 10 and Table 5.

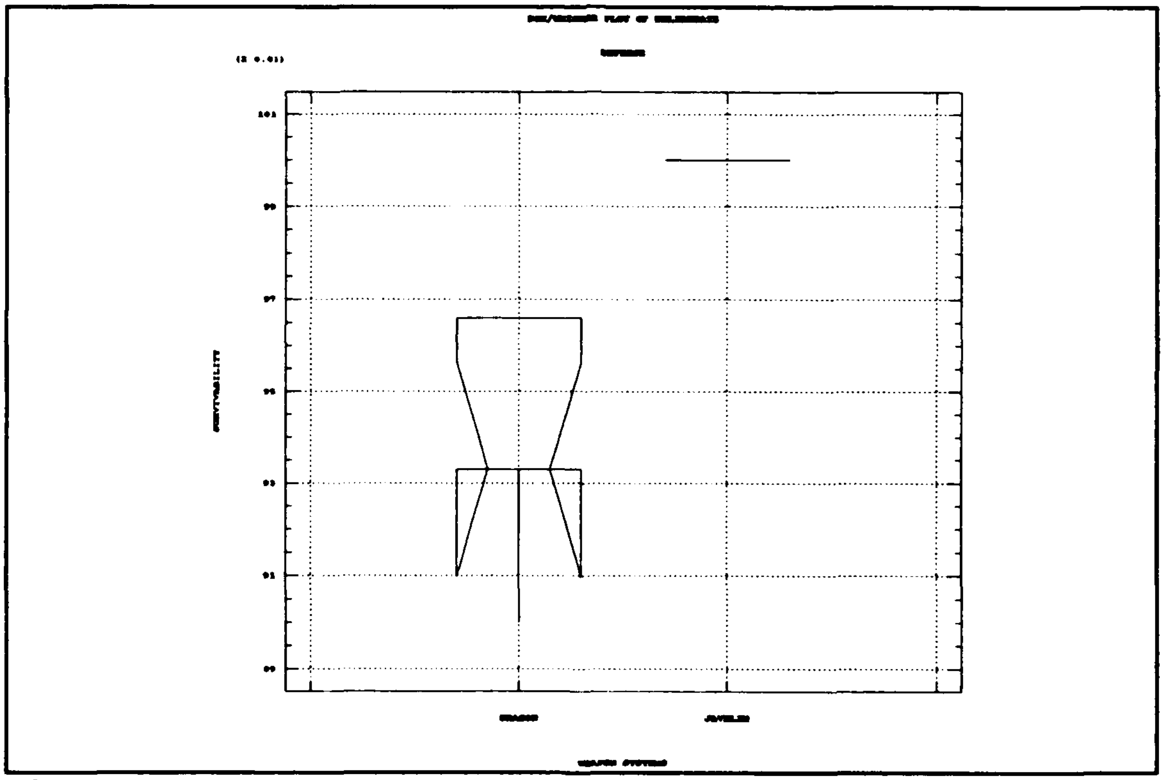


Figure 10

TABLE 5 ANOVA/KW VALUES FOR DELIBERATE DEFENSE

	ANOVA		KW	
	Test Statistic	P - Value	Test Statistic	P - Value
Range	14514.2	.0000	6.818	.0090
Lethality	42.885	.0002	7.031	.0080
Survivability	23.929	.0012	7.867	.0050

3. Deliberate Attack.

- Average Engagement Range: Analysis of the deliberate attack scenarios indicate that the medians are different. Median for the Dragon is 750 meters and the Javelin is just over 1700 meters. ANOVA and One Way Analysis of Ranks show distinct means/means of rank for the weapons. See Figure 11 and Table 6.

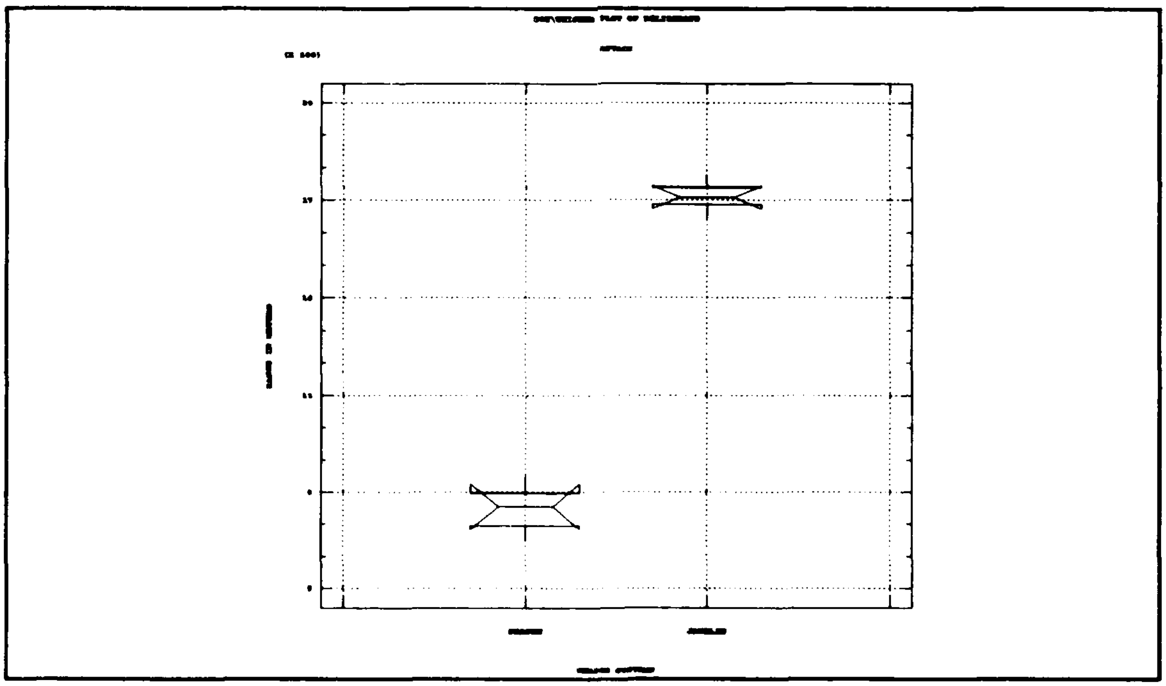


Figure 11

- Lethality: Medians for lethality are dissimilar. The Dragon's median is under 25% while the Javelin's is 50%. Again their confidence intervals do not overlap. Their ANOVA and KW values display differences to a five percent level of significance. See Figure 12 and Table 6.

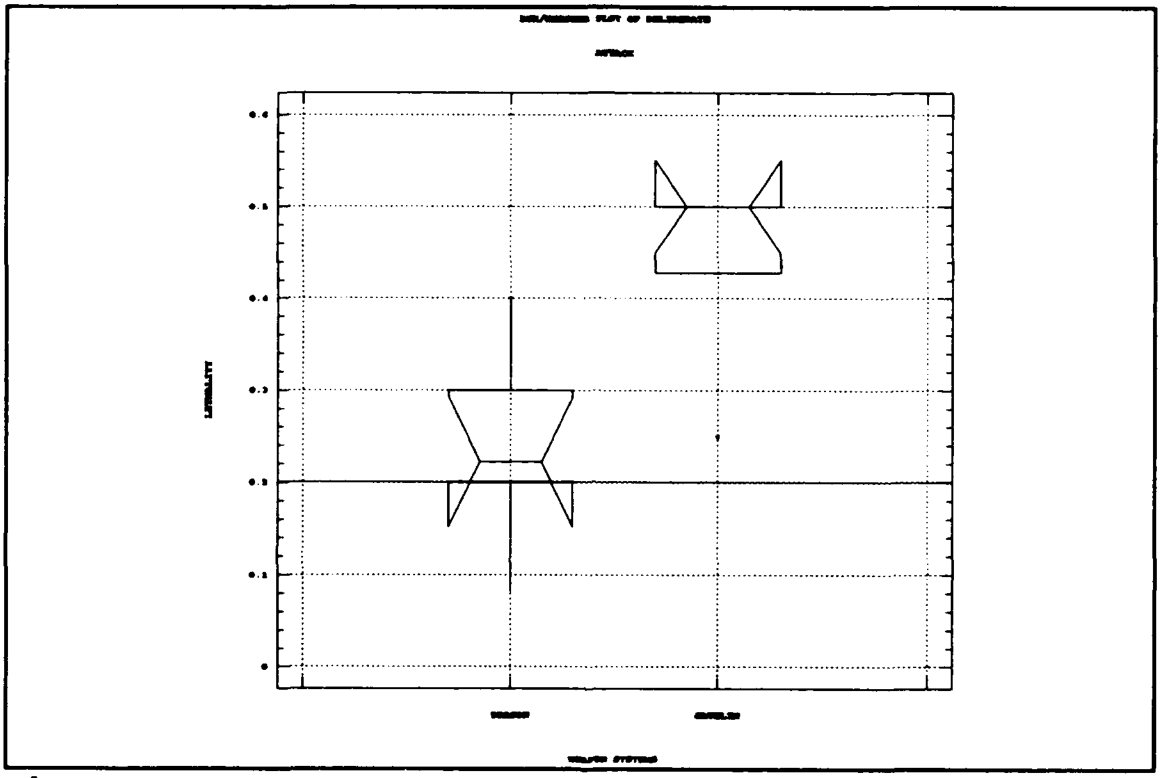


Figure 12

- Survivability: The medians for survivability are distinct. The Dragon's is 81% and the Javelin's is 97%. ANOVA and KW analysis support differences to a five percent level of significance. See Figure 13 and Table 6.

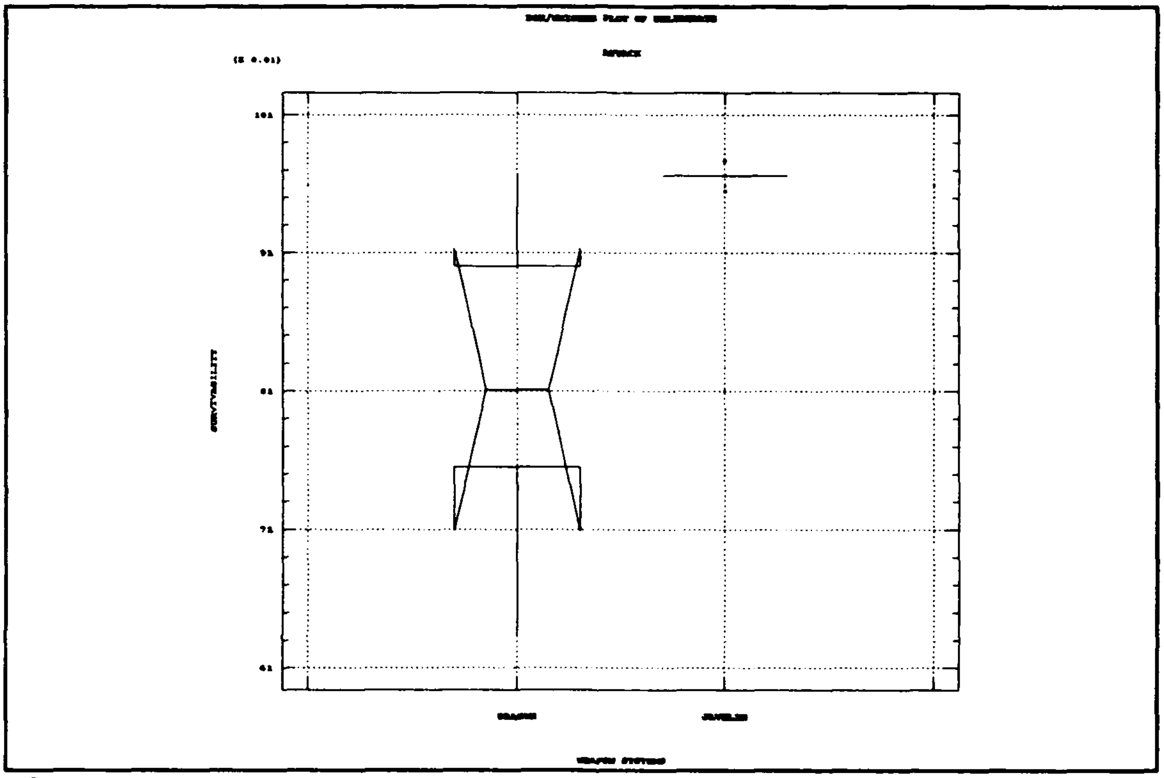


Figure 13

TABLE 6 ANOVA/KW VALUES FOR DELIBERATE ATTACK

	ANOVA		KW	
	Test Statistic	P - Value	Test Statistic	P - Value
Range	525.526	.0000	6.818	.0090
Lethality	7.374	.0264	4.930	.0263
Survivability	6.989	.0295	4.645	.0311

4. Movement to Contact.

- Average Engagement Range: Analysis of the Movement to Contact scenarios show significant differences for the medians. The Dragon's median is approximately 960 meters while the Javelin's is close to 1720 meters. ANOVA and KW analysis support dissimilar means/means of rank for the weapon systems. See Figure 14 and Table 7.

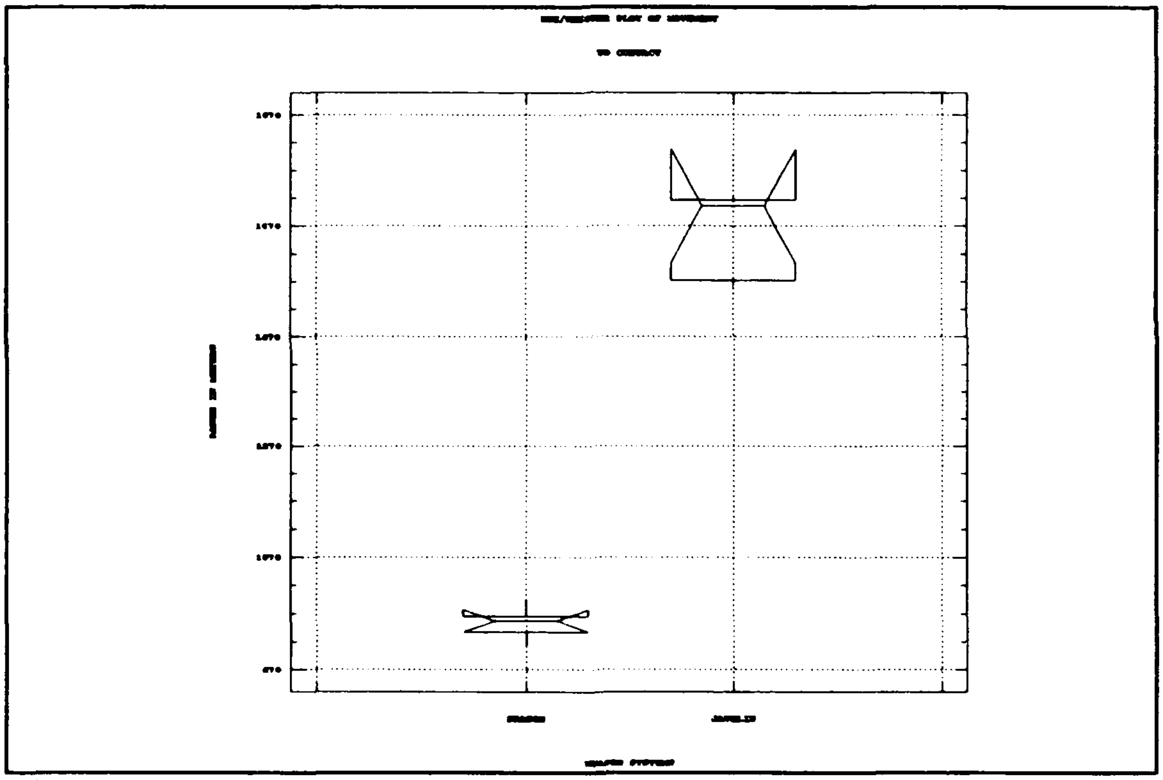


Figure 14

- Lethality: Medians for lethality are statistically unique. The Dragon's lethality is under 25% while Javelin's is 65%. ANOVA and KW analysis reject the equality of means and means of rank. See Figure 15 and Table 7.

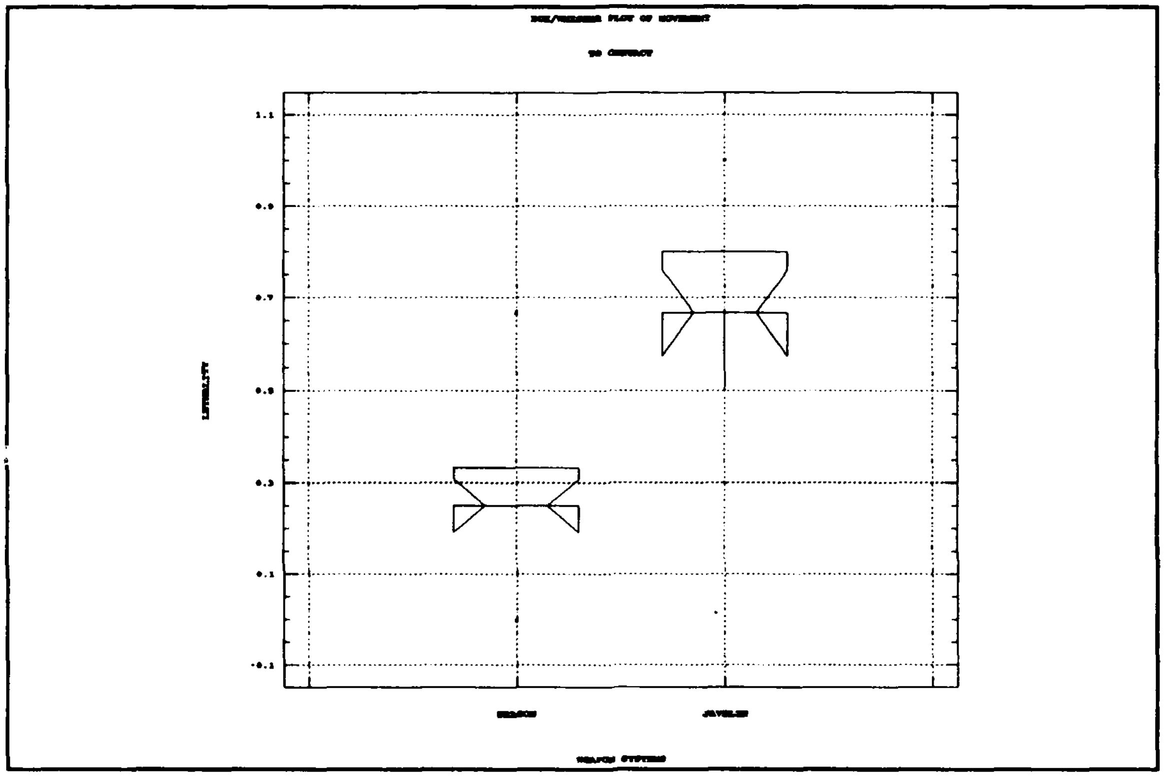


Figure 15

- Survivability: The survivability for the two weapon systems are again statistically different. The Dragon's median is under 60% while the Javelin's is approximately 98%. Values for ANOVA and KW reject similarities to a five percent level of significance. See Figure 16 and Table 7.

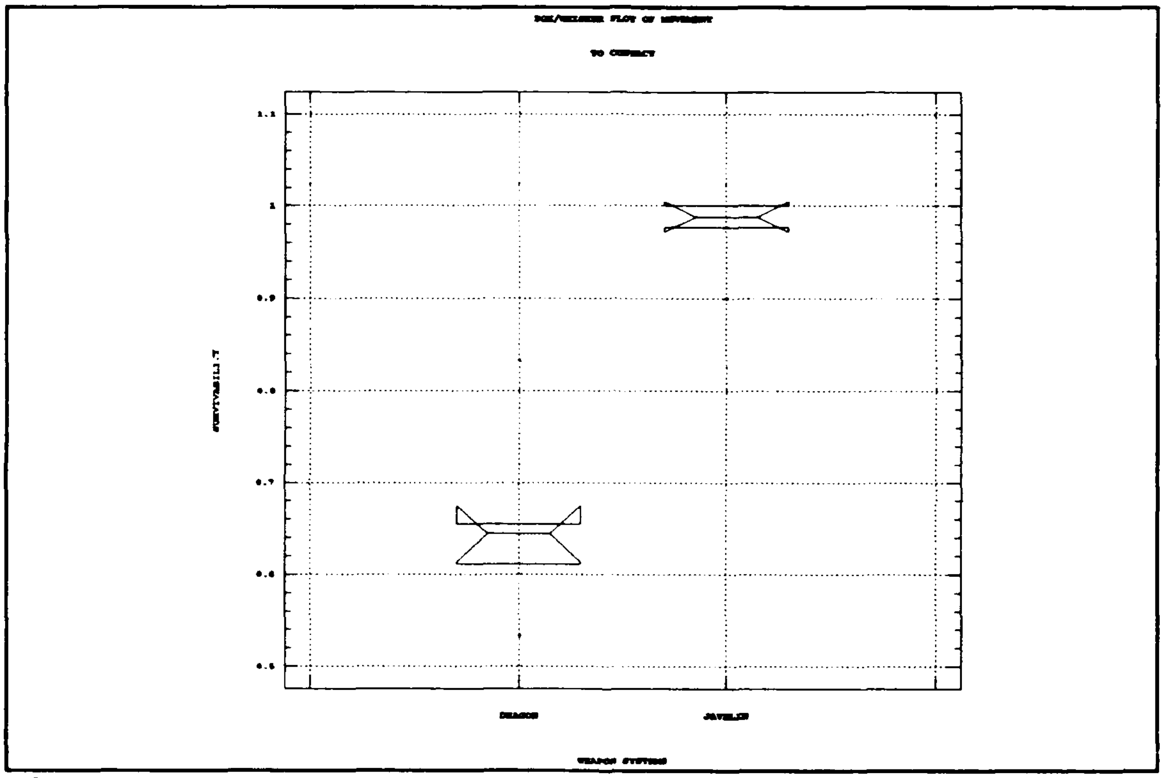


Figure 16

TABLE 7 ANOVA/KW VALUES FOR MOVEMENT TO CONTACT

	ANOVA		KW	
	Test Statistic	P - Value	Test Statistic	P - Value
Range	331.679	.0000	6.818	.0090
Lethality	9.863	.0138	4.961	.0259
Survivability	36.295	.0003	6.859	.0088

5. Hasty Defense in MOPP4 with Increased Basic Load

- Average Engagement Range: Results of the Hasty Defense in MOPP4 with Increased Basic Load display dissimilarities in the medians in the weapon systems for average engagement range. The Dragon's median is approximately 960 meters and the Javelin's median is 1980 meters. ANOVA and KW analysis support differences between the means and means of rank to a five percent level of significance. See Figure 17 and Table 8.

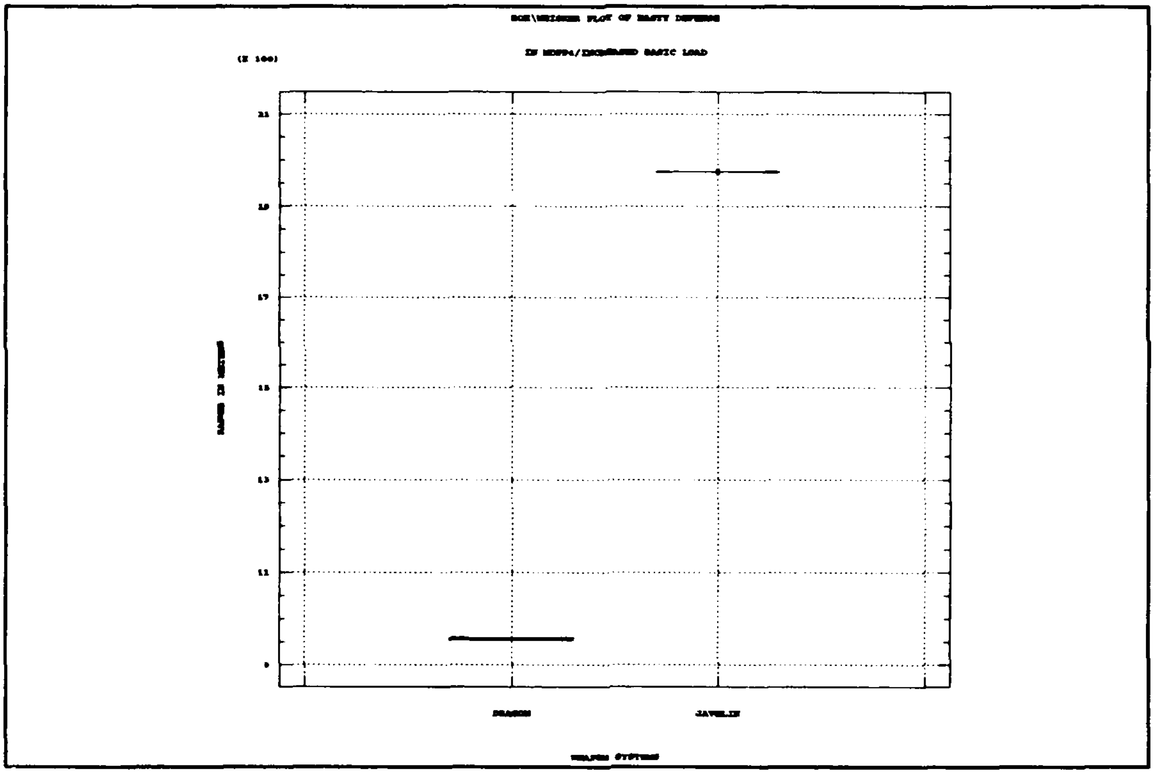


Figure 17

- Lethality: Differences in the medians are again apparent. The Dragon's median is 30% and the Javelin's is 80%. ANOVA and KW also show statistical differences to a five percent level of significance. See Figure 18 and Table 8.

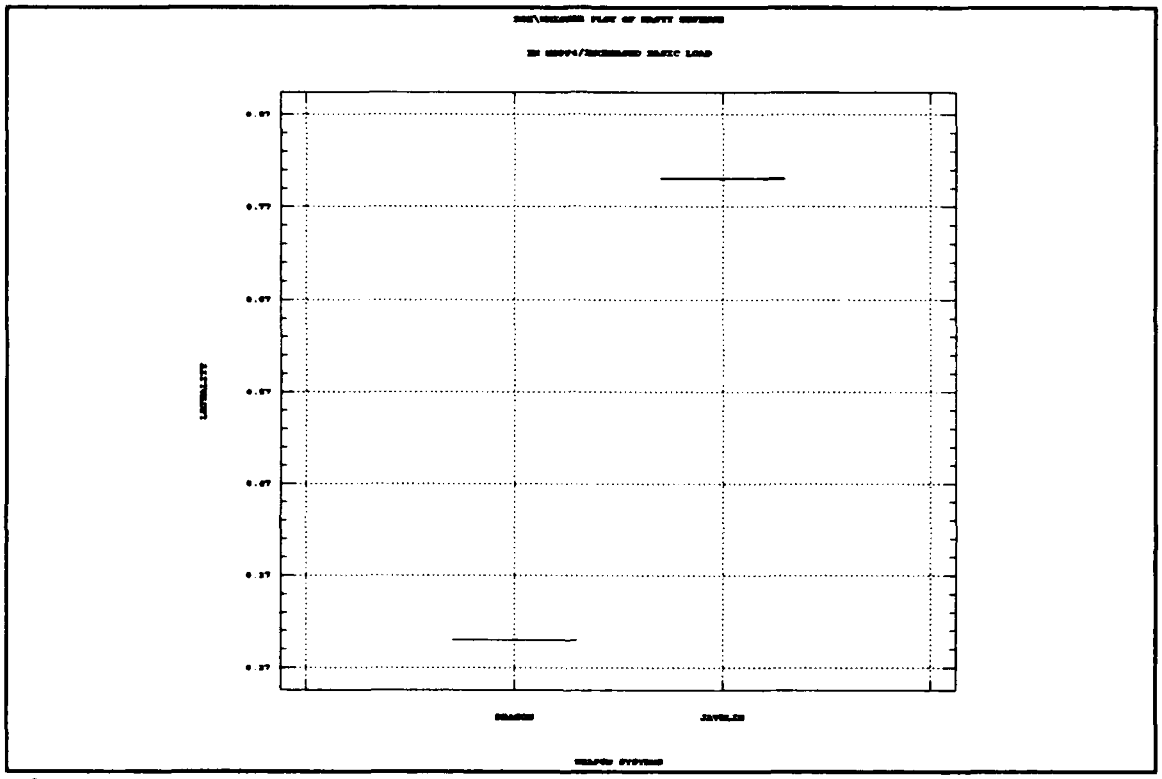


Figure 18

- Survivability: There are statistical differences between the medians of the weapons. The Dragon's median survivability is 90% while the Javelin's is approximately 93%. From ANOVA and KW analysis, their means/means of rank are dissimilar to a ten percent level of significance. See Figure 19 and Table 8.

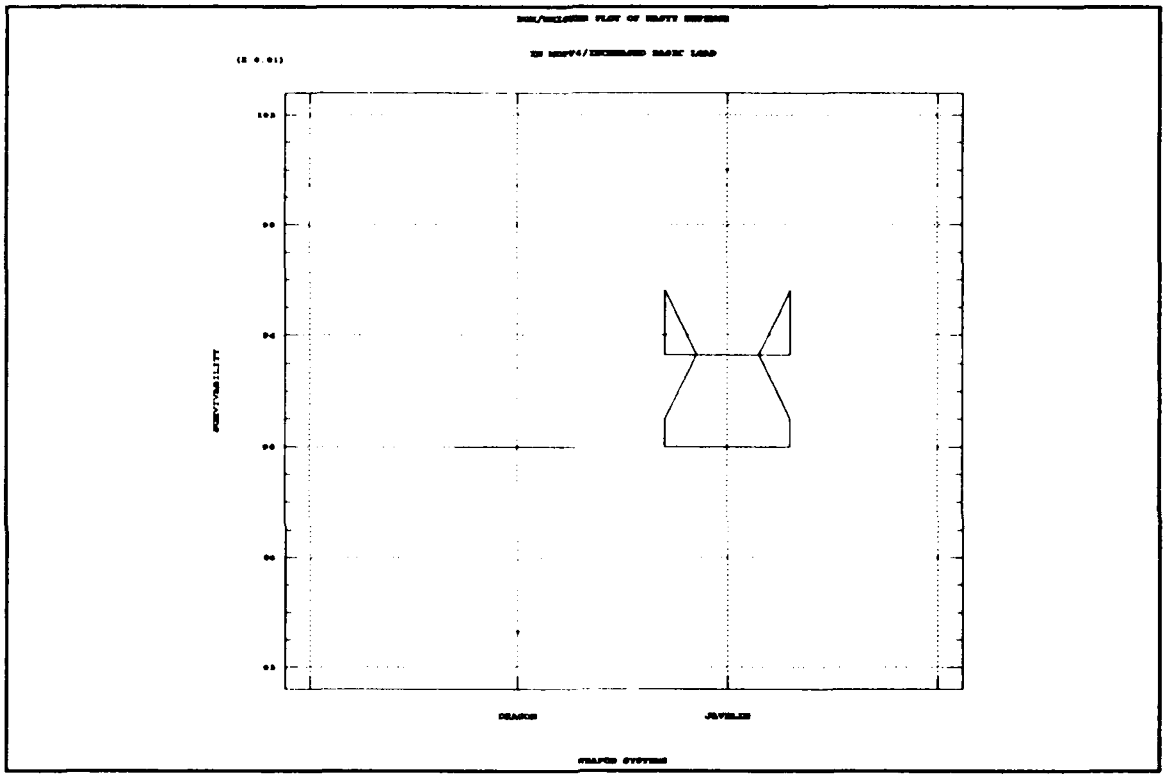


Figure 19

TABLE 8 ANOVA/KW VALUES FOR HASTY DEFENSE SCENARIOS

	ANOVA		KW	
	Test Statistic	P - Value	Test Statistic	P - Value
Range	354766	.0000	6.944	.0084
Lethality	6250	.0000	9.000	.0026
Survivability	4.234	.0736	4.033	.0446

6. Trends.

Given the terrain modeled in Janus, analysis supports the assumptions that the current operational tests planned for the MAW will support determining differences between the competing weapons systems. Pretest modeling indicates that across all scenarios and conditions average engagement range for the Javelin remains over two times that of the Dragon. For defensive operations the Dragon's lethality varies from 35%-50% while Javelin's lethality varies from 80%-100%. Lethality is lower in offensive operations. It varies from 22%-28% for the Dragon and 50%-65% for the Javelin. The lower lethality for offensive operations is intuitive because in defensive operations the weapons' fields of fire are selected to maximize the tactical advantage and therefore maximize lethality. In offensive operations the gunners employ their weapon system at the point they detect the enemy and can engage the target. That location may not necessarily have optimal fields of fire. Survivability shows trends not only in offensive versus defensive operations but also shows sensitivity to basic load. Javelin displays a greater survivability in the offensive operations and as the basic load is varied in the defensive operations.

It is important to understand what the MOE ratios represent for lethality and survivability. In the defensive operations the difference in survivability equates to one to three soldiers lives per platoon or expanding to battalion level nine to twenty-seven more soldiers survive. The number of lives saved is even more staggering for the offensive operations. Fourteen to thirty more soldiers survive per platoon. That represents almost a company at battalion level or one quarter of the fighting force in a five company battalion.

As stated earlier, conservation of testing resources is as important today as it has ever been. The pretest modeling results indicate close similarities between the defensive operations - hasty defense with increased basic load and deliberate defense, as well as the offensive operations - deliberate attack and movement to contact. Using one defensive scenario and one offensive scenario is a consideration which would reduce and streamline testing resources to include saving potentially millions of dollars. [Ref. 20] This postulation only considers issues addressed in the discussed MOE and not those of suitability.

VI. CONCLUSION/RECOMMENDATIONS

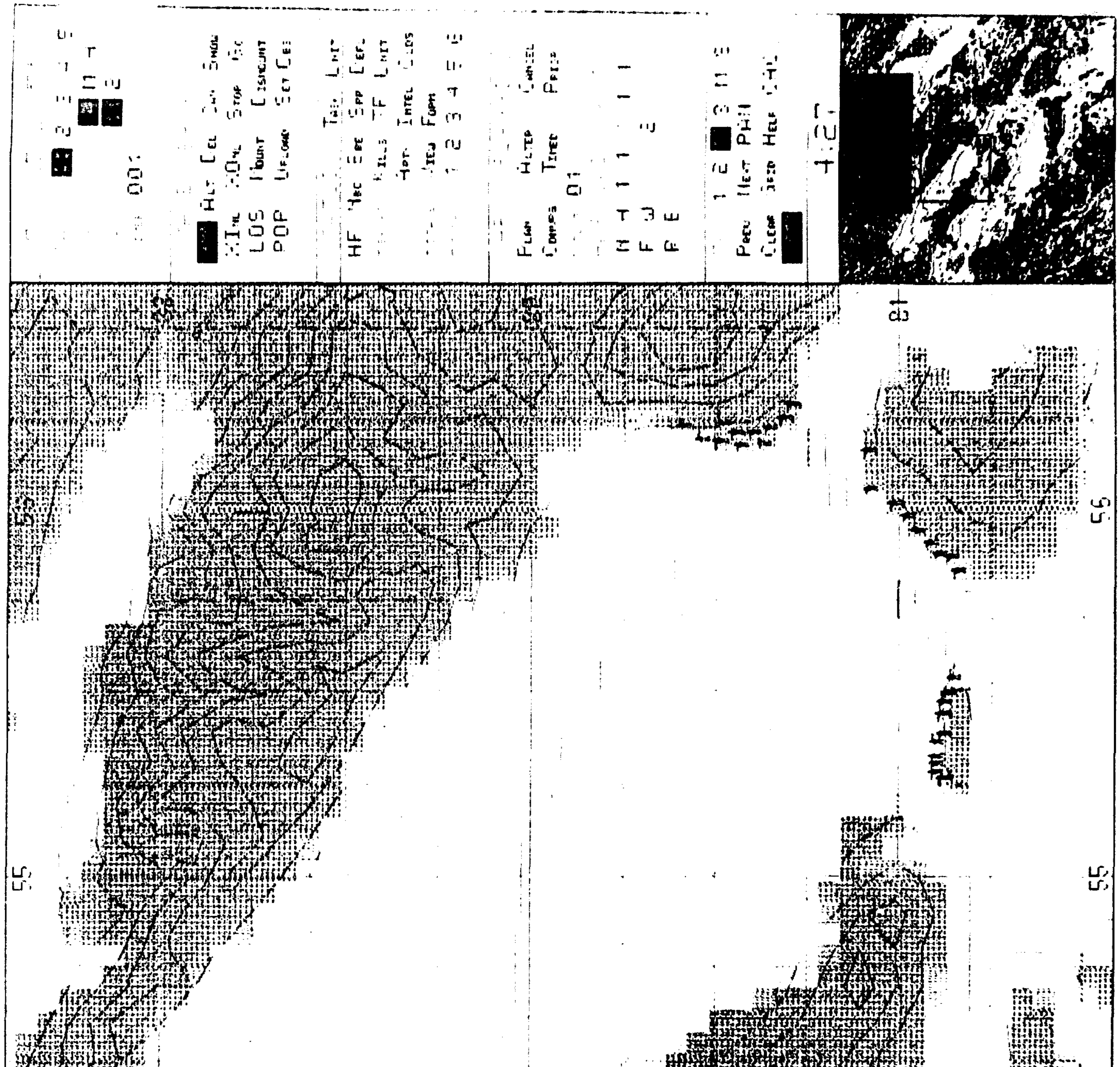
The first issue examined in this thesis is whether or not Janus(A) could adequately represent the differences between the MAW systems. In other words, is the model suitable for MAW MTM purposes. Such physics based issues as lethality, range and speed of the round as well as velocity of dismounted soldiers and vehicles are represented in Janus(A) adequately. Those attributes are simply data inputs. Due to the lack of object representation in Janus, replication of reality in terms of terrain and vegetation is not achieved in Janus. However, if the notion of probabilistic representations of terrain and vegetation is acceptable, then the Janus representation is acceptable. In that case, whether or not a soldier is exposed to fire or not can be expressed in the probabiilty of his detection. Of a smaller impact, the difference between being able to acquire and fire from a full defilade position is an issue that needs to be addressed if the model is to more nearly approach reality.

The second issue of whether the proposed scenarios are sufficient or effective to examine the differences between the weapon systems is affirmed. Modeling the TEXCOM weapon scenarios indicate that the differences in the weapon systems, shown by the MOE, should result during the operational test. Using various analysis tools to investigate the Medians, Means and Means of Rank all three support the alternate hypothesis that the median/means/means of ranks of the MOE are statistically different for the weapon systems. Engagement range, lethality and survivability for the deliberate defense, deliberate attack and movement to contact/hasty attack are different to a five percent level of significance.

Basic load is a condition that surfaces as an identified issue which impacts directly on one of the primary MOE - survivability. Survivability becomes significant at a five percent level when the basic load was increased from three to five rounds per system for the hasty defense in a Chemical/NBC environment. Hence, basic load is an important issue identified by this analysis and not addressed in the COIC but should be prior to the operational test. Based on the results of the initial pre-test modeling in Janus(A) the given scenarios and MOE are acceptable to show differences in the weapon systems if the systems are employed on the same or similar terrain at Fort Hunter – Liggett, which <u>maximizes</u> the capabilities of the weapon systems. Finally, this thesis considered reduction of the scheduled testing for possible test savings. The pre-test modeling results show enough similarities between the two defensive scenarios and offensive scenarios so that the operational test could be streamlined to make it more efficient.

APPENDIX A

Appendix A is a color copy of the Janus(A) screen display. It represents terrain from Fort Hunter Liggett, California and is a platoon deliberate defense. The enemy is attacking from West to East. The red line represents a Javelin's fire and kill of a T-72 tank.



APPENDIX B

Bartletts Test		
	Test Statistic	P - Value
Hasty Defense MOPP4		
Range	1.25	0.20
Lethality	1.02	0.70
Survivability	1.86	0.04
Hasty Defense MOPP4/Increased Basic Load		
Range	1.01	0.79
Lethality	0	0
Survivability	1.05	0.56
Deliberate Defense		
Range	2.24	0.02
Lethality	1.00	0.99
Survivability	0	0
Deliberate Attack		
Range	1.07	0.47
Lethality	1.00	0.87
Survivability	8.33	0.00
Movement to Contact		
Range	1.50	0.09
Lethality	1.03	0.63
Survivability	1.50	0.09

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