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ARTILLERY SURVIVABILITY IN
MODERN WAR

Final Report

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HISTORICAL EVALUATION AND RESEARCH ORGANIZATION
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55 Artillery Survivability in Modern War
(1976)

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HISTORICAL TRENDS IN ARTILLERY VULNERABILITY,
A HERO Concept Paper

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ARTILLERY SURVIVABILITY IN MODERN WAR (Phase One)

Introduction

HERO has been requested by Sandia Laboratories to undertake a study of Artillery Survivability in Modern War. It was envisaged that the first phase of this study would be a two-month effort to locate data and data sources. If the results of the Phase One data search warranted, in Phase Two additional data would be compiled, and the expanded and consolidated data base would be analyzed in terms of significance to both artillery vulnerability and artillery survivability.

HERO's terms of reference for the Phase One study were as follows:

"Accomplish research to provide a historical data base of artillery losses in combat. The data to be accumulated is a list of all known enemy-inflicted losses of artillery battery assets. The data base is to include the extent of the damage, estimates of the amount and type of counterbattery fire, location of the damaged elements on the battlefield, and other pertinent information contributing to the event.

"Campaigns to be analyzed are:

- "1. October 1973 War,
- "2. Eastern Front World War II battles where data is available,
- "3. Korean War prior to stalemate. . . .

"It is recognized that the detail of the report is affected by the time spent in research. . . 120 man-days of professional effort."

At the outset both HERO and Sandia realized that the time available for this study would not permit time-consuming, laborious extraction of data from the basic sources: unit records and reports. Thus it would be necessary to seek compilations of artillery loss data--at division level or higher--over significant periods of time. It was further recognized that such compilations would be scanty. In fact, as discussed in Part I of this report: "The Search for Data," there was even less data available than had been expected.

Nevertheless, while less specifically detailed than had been hoped for, a number of fragments of data were available, and have been compiled,

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permitting the detection of clear patterns and trends in artillery losses and vulnerability from World War II through the October 1973 War. Furthermore, the existence of substantial raw data in unit records and reports (US and German) was confirmed, indicating that an adequate data base can be compiled and analyzed in Phase Two.

The following members of the HERO Staff were engaged in this research: John A.C. Andrews, Col., USAF, Ret.; T.N. Dupuy, Col., USA, Ret.; Grace P. Hayes; Vivian E.L. Lyons; Paul Martell; and Lucille M. Petterson. Research was conducted at the National Archives, Washington, D.C.; at the Federal Records Center, Suitland, Maryland; at the Army Materiel Systems Analysis Agency, Aberdeen Proving Grounds, Maryland; Training and Doctrine Command Headquarters, Fort Monroe, Virginia; The Army Library, The Pentagon, Washington, D.C.

The undersigned assumes full responsibility for the report.

Dunn Loring, Virginia
October 13, 1976

T.N. Dupuy

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Part I. The Search for Data

Relevant Prior Studies

In order to profit from previous work done on the subject of artillery survivability and avoid duplication of effort, concurrent with the search for artillery loss data for the October War, the Korean War, and the Soviet-German theater in World War II, HERO researchers attempted to find other studies on the same or similar topics. Not only did their search in US, British, German, and Russian sources fail to yield any compilations of data or quantified analyses of historical experience of loss of artillery or counterbattery performance, conversations with members of the US Army Materiel Systems Analysis Agency (AMSAA) and the Artillery Section at the US Army Training and Doctrine Command (TRADOC) and correspondence with the US Army Field Artillery School at Fort Sill, Oklahoma, indicated clearly that none are available.

In addition to staff visits to AMSAA at Aberdeen Proving Ground (two visits each by two HERO staff members) and to TRADOC at Fort Monroe (one visit by one HERO staff member) and correspondence with the Commanding General of the Field Artillery School, the following documentary searches were carried out:

A computer document search was made by the Defense Documentation Center. Inspection of microfiche of the documents it yielded produced no general studies on the subject. Although three documents appeared to have some material on specific losses, it proved to be insufficient for the purposes of the study.

A computer document search by the Defense Intelligence Agency produced no studies of value.

Search of the files of the Research Analysis Corporation (now the General Research Corporation) produced two studies that were inspected by a staff member, but they contained nothing directly relevant to this subject.

The October War

The most accessible source of data related to the October War was the files of HERO, which contain a substantial collection of classified and unclassified material gathered for other studies. All October War data in this Unclassified version of the report came from HERO's unclassified files.

The Korean War

HERO's study, "Historical Analysis of Wartime Replacement Requirements; Experience for Selected Major Items of Combat Equipment" (HAWRR), was reviewed, and some of the sources used for the analysis of the experience of the two divisions therein were reexamined. It was found, however, that this experience was too atypical to be of value for this study.

Two members of the HERO staff consulted the official records of US Army units in the Korean War, including the Far East Command, Army Forces Pacific, Eighth Army, I Corps, IX Corps, and various divisions and field artillery battalions at the Federal Records Center, Suitland, Maryland. The collection of records is large and not indexed. In the time available only samplings could be made. The results were disappointing in that data was insufficient for any valid use in this study. It is clear that only a systematic investigation of all files pertaining to artillery units and experience could give a realistic, useful picture of artillery survivability in the Korean War.

World War II

Data pertaining to experience on the eastern front was sought in both German and Russian sources. Seventeen Russian publications were examined, but no data relevant to this study was found. At the National Archives the microfilmed records of German military units were consulted. It was decided to concentrate on Army Group Center, and initially on the Ninth Army. A sampling of records of the artillery commander of that army yielded no statistics on artillery losses. After a chance discovery of artillery reports from the Fourth Army, a portion of the records of that army were searched, and sufficient data was retrieved to make it possible to analyze the Fourth Army's experience for the month of November 1943. Time limitations prevented acquisition of data for a longer period.

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A thorough review of data in HERO's files, taken for earlier studies on other subjects from the microfilmed German records, produced a large collection of miscellaneous data, but none of it adequate for meaningful presentation. However, sufficient statistics on the strengths and losses of the entire German Wehrmacht in World War II were available for three months of 1944. Similar statistics for a longer period can be obtained from the source of these, the German Document Center at Freiburg, FRG, but this was impossible in the time available for this study.

The data in HERO's HAWRR study, which had originally been compiled from official contemporary records, augmented by some statistics in HERO's data base, was reviewed and used for the portion of the report dealing with the US First, Fifth, and Tenth Armies. The data on the Seventh Army in that report was obviously incomplete and was discarded. Data on the Third Army was taken from the Army's After Action Report and from records of the 12th Army Group at the National Archives.

Manufacturing Data

In the absence of any known body of data on real world artillery survivability in combat, AMSAA has developed an Artillery Force Simulation Model (AFSM). AMSAA scientists and operations research analysts have introduced into this all possible experimental test data on the survivability and vulnerability of individual items of United States and potentially hostile equipment, on the effectiveness or lethality characteristics of our own and potentially hostile weapons and ammunition, and reasonable operational assumptions based upon known doctrine and tactics of our own and hostile forces.

This model was described to two members of the HERO staff by Messrs. Odom and Chandler of AMSAA. The results from a number of model runs are believed by AMSAA scientists to be reasonable, but they have no way of validating the model with historical data.

More Data is Available

HERO's experience in research for its 1966 HAWRR Study and for this study have demonstrated that US Army artillery loss data is available in primary sources for both World War II and the Korean War. There is also considerable data available on German artillery losses on all fronts in World War II. Furthermore, it seems reasonable to expect that the discrepancies noted in the data from Israeli sources on the October War can be reconciled with assistance from the IDF.

To get the data from the American and German records will take a major research effort. Nevertheless, for reasons pointed out below and in the Conclusions of this study, such a body of data is essential to the development of reliable, real-world data on artillery vulnerability and survivability.

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Most of the artillery weapons in World War II were towed weapons. By the time the United States had committed small but significant numbers of self-propelled artillery pieces in Europe, German air and artillery counter-battery retaliatory capabilities had been significantly reduced. In the Korean and Vietnam Wars, although most American artillery was self-propelled, the enemy had little counter-artillery capability either in the air or in artillery weapons and counter-battery techniques.

It is evident from vulnerability testing of current Army self-propelled weapons, that these weapons--while offering much more protection to cannoneers, and providing tremendous advantages in mobility--are much more vulnerable to hostile action than are towed weapons, and that they are much more subject to mechanical breakdowns involving either the weapons mountings or the propulsion elements. Thus there cannot be a direct relationship between aggregated World War II data, or even aggregated Korean War or October War data, and current or future artillery configurations. On the other hand, the body of data from the October War where artillery was self-propelled is too small and too specialized by environmental and operational circumstances to serve alone as a paradigm of artillery vulnerability. However, analysis of the raw data from these previous wars, combined with the results of recent weapons vulnerability testing and the operation of AMSAA's AFSM should demonstrate trends and relationships that will permit the development of good data on artillery vulnerability.

Just as this study was being completed HERO learned that there is some artillery loss data from the Vietnam War in the Army Maintenance Management Systems (TAMMS) Loss Data at Letterkenny Army Depot. This data starts in Fiscal Year 1967 and continues through 30 September 1974. Apparently some effort has been made, either at AMSAA or at the Army's Concepts Analysis Agency (CAA), to relate the TAMMS Loss Data for all equipment (including artillery) with the RAC model on combat equipment losses which was based, at least in part, on HERO's HAWRR Study.

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Part II. The Data

General

The principal problem encountered in trying to put together in meaningful form the substantial number of available bits and pieces of artillery loss data was that of context. The loss of ten artillery pieces to enemy action is catastrophic, if this loss is incurred by a division in a week. It is considerably less significant if it is a loss reported by an army over a period of two months. Thus, to have relevance in this report, a body of data required the following characteristics, at a minimum:

- a. Identification of the formation to which the artillery belonged, including overall personnel strength at the beginning of the data period;
- b. Exact length of the data period in days;
- c. Total personnel losses of the formation to which the artillery belonged for the data period;
- d. Number of artillery pieces belonging to the formation at the beginning of the data period, by caliber or by weight characteristics, if possible;
- e. Total losses of the formation's artillery, by type or category or weapon, if possible, and with indication, if possible, whether all of the losses were caused by hostile action or whether accident losses are included, and if so, how many.

US Data, World War II

In its HAWRR Study HERO compiled considerable information about losses of various significant items of equipment, including light and medium howitzers, for World War I (one brief combat period for one division only), the Korean War (brief combat periods for two divisions only), and World War II.

The World War II data surveyed in that study covered extended periods of combat for the following units: First Army, Fifth Army, Seventh Army, Tenth Army, and the following infantry divisions: 1st, 7th, 25th, 28th, 45th, and 96th; and the 6th Armored Division. A review of the study and its background data revealed that (with some additional data on First and Fifth Army operations in Europe available in HERO files), the data on the First, Fifth, and Tenth Armies could provide useful information on the artillery losses of those armies over extended periods of combat, and also (except for the Tenth

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Army) for some briefer periods of more intensive combat. The data on the Seventh Army was obviously incomplete, and there was no additional data in HERO files from which this could be augmented and no time for further research.

The data on the divisions showed one thing relevant to this study: artillery losses of towed US weapons in World War II were infrequent. Otherwise this data, compiled for an entirely different purpose, was not adaptable to the purposes of this study without additional considerable research. (For this reason the data on the 77th Division in World War I, and the 2d and 25th Infantry Divisions in the Korean War, was not adaptable to this study in the brief time available.)

Information on personnel strengths and losses and artillery losses for the First, Fifth, and Tenth Armies was taken from the HAWRR Study and from other material in HERO's data files. Artillery strengths were not included in that study, but partial data on that was found in other sources at HERO. Data on the US Third Army was taken primarily from that army's After Action Report. Figures on artillery strengths for the four armies were not readily available for the entire periods covered, and it was necessary to extrapolate some figures from orders of battle, which are more likely to be available, and from other historical evidence. Had time permitted further research it is unlikely that the figures used would prove to be as much as 10% in error.

Since the data relating to the US First Army permitted it, it has been possible, for that army only, to show strengths and losses for heavy artillery.

Although there is data on the causes of losses available for isolated incidents, it was not possible within the limitations of this study to compile it. In order to make some assessment it has been arbitrarily assumed that 20% of the losses reported resulted from accidents and 80% were the result of enemy action, i.e., combat losses.

Data for determining the approximate ratio of artillery pieces with respect to enemy strengths is readily available only for the US Fifth Army from April through August 1944. It is estimated that the ratios for the First and Third Armies and their opponents would have been comparable.

US First Army

Two sets of data are shown for the First Army. The first of these covers the entire period 1 August 1944 to 22 February 1945. The second is for the first ten days of the Battle of the Bulge, in December 1944. The artillery strength for 16 December has been estimated but is considered by HERO to be accurate within 5%. It was ascertained from secondary sources that in those first ten days of the Bulge, the First Army was forced to abandon about eighteen 105mm howitzers (mostly from the 106th and 28th Infantry Divisions), and about four 155mm howitzers. These numbers have been listed as "other" in Figure 1, and the remainder of the combat losses

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(estimated at 80% of total losses) have been listed as losses to artillery, since they could not have resulted from German air attacks. They are also assumed for the longer period to have been the only losses in the First Army to causes other than counterbattery fire, because of the nature of the combat experience of the army during those months.

US Third Army

Data for the US Third Army is included in Figure 1 although it is far from complete. Personnel strengths and losses in HERO's files, taken from the records of the 12th Army Group, were available only for the three months shown. Since only overall artillery losses were found, there is no breakdown by types of weapons. Causes of losses were not discovered and have not been shown.

US Fifth Army

Three sets of data are shown for the US Fifth Army, covering these periods: (1) 9 September 1943 to 16 September 1944; (2) 21 January to 30 March 1944, during the period of intensive operations at Anzio and along the Rapido River; and (3) 14 May to 10 June 1946, the most intensive period of the Rome campaign. It has been necessary to rely on widely separated orders of battle for the artillery strengths. The breakdown of causes of artillery losses is based upon information on the intensity and character of the operations in secondary sources.

US Tenth Army

The data used for the Tenth Army in the period 1 April to 30 June 1944 is that assembled for the HAWRR Study. Artillery strength figures are based on known availabilities in the Pacific Theater.

German Data

The statistics on personnel strength of the entire German Wehrmacht shown in Figure 2 were taken from, or extrapolated from, several German sources used in HERO's study, "German and Soviet Replacement Systems in World War II." Since approximately 19% of the overall Wehrmacht on the average during the war was in the Replacement Army, 81% is shown here as the strength of the field army. On the basis of considerable experience with personnel strengths for other HERO studies it is assumed that about 60% of the field army was in units actually engaged in combat missions. These figures are combined in Figure 3 with data from another source on total artillery strengths and losses by type of weapons for the entire Wehrmacht during the months of August and September 1944. The first of these was probably the most disastrous month of the war for Germany. It has been assumed that these strengths are weapons actually issued and available in combat units.

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Figure 1. SELECTED ARTILLERY LOSS DATA, US FORCES, WORLD WAR II

Operation Designation Organization - Date	Average Total Force Strength	Losses	%	%/Day	Artillery Weapon	Av Str	Approx Ratio to Enemy	Total Losses	Combat Number	%/Day	Losses to Air	Losses to Artillery	Losses to Other
WW Europe, World War II													
US First Army 1 Aug '44-24 Feb '45 (206 days)	291,660	118,319	40.57	0.196	240 H 155 G (Hvy Total)	22 124 146		1 4 5	1 3 4	0.022 0.012 0.013	0 0 0	1 3 4	0 0 0
					155 H 105 H (L&M Total)	252 354 606		23 45 68	18 36 54	0.035 0.049 0.043	0 0 0	14 18 32	4 18 22
					Total	752	2.50/1.0*	73	55	0.037	0	36	22
US First Army 16-26 Dec '44 (11 days)	334,399	20,438	6.11	0.556	155 H 105 H Total	240 408 648		10 31 41	9 28 37	0.341 0.624 0.519	0 0 0	5 10 15	4 18 22
US Third Army Oct-Dec '44 (92 days)	254,302	57,707	22.69	0.247	155 H 105 H Hvy Total	246 492 160 898		- - - 31	- - - 25	- - - 0.030	- - - -	- - - -	- - - -
Italy, World War II													
US Fifth Army 9 Sep '43-16 Sep '44 (372 days)	180,400	78,371	43.44	0.117	155 H 105 H Total	76 216 292		29 49 78	23 39 62	0.081 0.049 0.057	2 2 4	21 31 52	0 6 6
US Fifth Army 21 Jan-30 Mar '44 (68 days)	198,074	21,768	10.99	0.162	155 H 105 H Total	76 228 304	2.55/1.0 2.49/1.0	6 23 29	5 18 23	0.097 0.116 0.111	2 2 4	3 10 13	0 6 6
US Fifth Army 14 May-10 June '44 (28 days)	235,107	16,613	7.07	0.253	155 H 105 H Total	84 240 324	2.66/1.0	10 3 13	8 3 11	0.340 0.045 0.121	0 0 0	8 3 11	0 0 0
Okinawa, World War II													
US Tenth Army 1 Apr-30 June '44 (91 days)	153,670	39,420	25.65	0.282	155 H 105 H Total	84 156 240	2.05/1.0	2 11 13	2 9 11	0.026 0.063 0.050	- - -	2 9 11	0 0 0
*Estimates													

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Figure 2. WEHRMACHT STRENGTHS AND LOSSES, 1943-1944

Dates	Wehrmacht	Field Army	Losses	Replacements	Estimated Combat Zone Commitments
7/1/43	10,132,892	8,207,647	2,096,000	1,381,000	4,924,588
6/30/44	9,417,898	7,628,497	200,000	100,000	4,577,033
7/30/44	9,317,898	7,547,497	285,000	100,000	4,528,498
8/30/44	9,132,898	7,397,647	335,000	98,000	4,438,583
9/30/44	8,935,832	7,205,677			4,323,406

Figure 3. SELECTED ARTILLERY LOSS DATA, GERMAN FORCES, WORLD WAR II

Operation Designation Organization - Date	Av. Total Force Strength	Losses	%	Artillery Weapon	Total Str	Approx Ratio to Total Enemy*	Combat Losses Number	Losses to Air Losses	Losses to Artillery Losses	Losses to Other Losses
World War II										
Wehrmacht Field Army Combat Forces August '44	4,528,200	595,000	13.16	LFH MFH Hvy Arty Total L&M	8,524 2,898 1,461 12,883 11,422		1,170 248 104 1,522 1,418			
September '44	4,338,800	397,000	8.94	LFH MFH Hvy Arty Total L&M	8,230 3,023 1,430 12,683 11,253		336 113 13 462 449			
Average Month 1943-1944	4,525,194	182,917	4.04	LFH MFH Hvy Arty Total L&M	8,200 2,800 1,400 12,400 11,000		249 93 33 375 342			
East Front, World War II German Fourth Army November '43	179,279	8,844	4.93	Light M&H Total	290 180 470		9 9 18			
							8 8 16	1 1 2	6 6 12	1 1 2
							2.76 4.44 3.40	0.012 0.019 0.014	0.069 0.111 0.085	0.012 0.019 0.014

*Estimate; may be high for Germans.

From miscellaneous other sources and bits of data, a typical or average month's experience in 1943-1944 has been computed. In both cases the same breakdown of 80-20% was assumed for combat and noncombat losses.

The German Fourth Army in November 1943 was under Soviet attack near Orsha, north of Mogilev, in the center of the German Eastern Front. The statistics for this period were assembled from several official reports on various rolls of microfilm, including description of the cause of loss of each artillery piece.

The only readily available reliable data for comparing approximate German and Soviet artillery tube ratios is for one sector of the Battle of Kursk July 1943, where the Germans were making their main effort. The ratio there was 0.48/1.00. It is therefore estimated that the average ratio on the Eastern Front, and elsewhere, in 1944 could not have exceeded that for the Italian Front in May 1944 where it was 0.38/1.00.

October War Data

Locating Israeli and Arab data on artillery strengths and losses in the October War presented many problems. There is some classified data on Israeli strengths and losses available in documents made available to US military investigators after the October War. There are, however, serious discrepancies among different documents on these losses. Actually more unclassified estimates of Arab strengths and losses than of Israeli strengths and losses have been located in various newspaper and magazine accounts of the October War.

The following unclassified estimates are believed to be reasonably accurate for overall Israeli and Arab personnel and artillery strengths and losses:

Figure 4

	<u>Israelis</u>	<u>Arabs</u>
Personnel Strengths, overall	300,000	505,000
field forces	250,000	400,000
Personnel losses, killed and wounded	11,638	28,077
Percent loss	3.75%	5.56%
Artillery strengths (100mm and more)	620*	2,055
Artillery losses, overall	112**	550
Percent loss	18.04%	26.76%
	(4.81 x 3.75)	(4.81 x 5.56)

* Does not include approximately 50 Soviet 122mm and 130mm weapons captured in 1967.

** Israeli artillery loss estimates based upon Arab factors, and relationship of Arab artillery percent loss to Arab personnel percent loss.

Assuming that 20% of the Arab and Israeli artillery losses were now combat losses, this leaves Israeli combat losses of 90, Arab combat losses of 440. On the basis of World War II experience, approximately 25% of total loss was permanent combat loss. This results in total permanent combat loss of 28 for the Israelis, and 138 for the Arabs.

It is known that approximately 80% of Israeli artillery personnel losses were to Arab counterbattery, but that approximately half Israeli combat damage to artillery pieces was from Arab air attack. It is also understood that six to eight Israeli artillery pieces were knocked out by Syrian tanks. Causes of Israeli losses can therefore be roughly allocated as follows:

	<u>Overall</u>	<u>Permanent</u>
Losses to air - 45%	40	12
Losses to counterbattery - 45%	40	12
Losses to other ground action - 10%	<u>10</u>	<u>4</u>
TOTAL	90	28

Applying these same percentages to the Arab losses, we can estimate the causes of Arab artillery losses as follows:

	<u>Overall</u>	<u>Permanent</u>
Losses to air - 45%	198	61
Losses to counterbattery - 45%	198	61
Losses to other ground action - 10%	<u>44</u>	<u>18</u>

Based upon quantities shown in Figures 1 and 3, the allocations of weapons to major weight categories for both the Israeli and Arab armies were estimated as follows:

	<u>Israeli</u>	<u>Arab</u>
Heavy artillery - 15%	93	308
Medium artillery - 25%	155	514
Light artillery - 60%	<u>372</u>	<u>1233</u>
TOTALS	620	2055

Within the Israeli totals, further estimated breakdowns were made, as follows:

Heavy: 93 (all SP)	175mm gun, SP	33
	155mm gun, SP	60
Medium: 155 (all SP)	155mm how, SP	155
Light: 372 (half SP, half towed)	105mm how, SP	50
	160mm mor, SP	62
	120mm mor, SP	62
	120mm mor, towed	180

It is believed that the Israeli Army had approximately 50 additional Soviet-made 130mm guns, and 122mm gun-howitzers, all towed, captured from the Egyptians and Syrians in the 1967 War. It is assumed, however, that most of these would have been deployed on the static Jordan River front, and they have not been considered in this analysis.

Based upon the above assumptions and estimation, Figure 7 has been prepared, to provide statistical comparisons of artillery strengths and losses of the Israeli and Arab armies in the October War, comparable to those of Figures 1 and 3 for US and German forces in World War II.

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Part III. Analysis

General World War II Analyses

The data contained in Figure 1, Selected Artillery Losses, US Forces, World War II, relates weapons combat losses to overall artillery strengths to arrive at a figure of percent loss per day. This percent loss per day from all hostile action causes is further broken down, to the extent data is available, to losses from air attack, from artillery, and from "other causes." This is shown for periods of extended combat (91 days to 373 days) for four armies (US First, Third, Fifth, and Tenth), and for shorter periods of more intensive operations for the First and Fifth Armies. Personnel strengths and losses for the same period are shown in each case.

The data contained in Figure 3, Selected Artillery Losses, German Forces, World War II, provides similar data for the combat forces of the Wehrmacht for August 1944, September 1944, the period 1943-1944, and the Fourth Army on the Eastern Front in November 1943.

Figure 5 is a graphical plot of the American and German data in Figures 1 and 3; the symbols represent the following:

- 1.0a: US First Army, 206 days, artillery losses to all causes
- 1.0b: US First Army, 206 days, artillery losses to artillery
- 1.01a: US First Army, 206 days, artillery losses to medium and light weapons only
- 1.01b: US First Army, 206 days, artillery losses to medium and light weapons only
- 1.1a: US First Army, 10 days, Battle of Bulge, losses to all causes
- 1.1b: US First Army, 10 days, Battle of Bulge, losses to artillery
- 3a: US Third Army, 92 days, losses to all causes¹
- 5.0a: US Fifth Army, 373 days, losses to all causes
- 5.0b: US Fifth Army, 373 days, losses to artillery
- 5.1a: US Fifth Army, 68 days, Anzio-Cassino, losses to all causes
- 5.1b: US Fifth Army, 68 days, Anzio-Cassino, losses to artillery
- 5.2a: US Fifth Army, 28 days, Rapido-Rome, all causes¹
- 10a: US Tenth Army, 91 days, losses to all causes¹
- G-0a: German Field Army, 31 days, August 1944, losses to all causes
- G-1a: German Field Army, 30 days, September 1944, losses to all causes
- G-2a: German Field Army, 30 days, average 1943-1944, losses to all causes
- 4a: German Fourth Army, 30 days, November 1944, losses to all causes
- 4b: German Fourth Army, 30 days, November 1944, losses to artillery

Based upon these plots two curves have been tentatively drawn reflecting the weapons percent loss per day (WPLD) to personnel percent loss per day (PPLD) relationship. The relation of each plotted point to the curves is discussed below:

¹Artillery counterbattery was the only significant cause.

1.0a: The US First Army artillery losses (including heavy artillery) to all causes in a period of moderately active combat are considerably lower than the average. The reason for this is that, despite an extremely intensive but brief period of combat in December, the First Army was engaged against an enemy with a considerably lower than average artillery and artillery counterbattery capability.

1.0b: Same comment as above for losses to artillery.

1.01a: Same comment as above for medium and light artillery losses to all causes.

1.01b: Same comment as above for medium and light artillery losses to artillery.

1.1a: The estimated First Army artillery losses to causes other than air and artillery were considerably higher than "normal: in periods of such intensive combat, and suggest the truly disastrous effects of the German surprise achieved in the Battle of the Bulge.

1.1b: The First Army artillery losses to German counterbattery during this otherwise disastrous period appear to be normal, plotting very close to the estimated curve (which is a straight line).

3a: The US Third Army artillery losses, all or most to German counterbattery, were low for the same reason as were those of the First Army for a similar extended period.

5.0a: Fifth Army artillery losses for all causes plot somewhat below the estimated curve, since most Fifth Army losses in Italy, save for a short time at Anzio, were caused by German counterbattery.

5.0b: Thanks mainly to the terrain, the Germans were able to exploit the potential effectiveness of their artillery to the utmost in Italy against the US Fifth Army. Thus the plot of Fifth Army losses from German counterbattery in the relatively low intensity combat of a year's operations in difficult terrain is very close to the estimated curve.

5.1a: The intensity of the German reaction to the Allied landing at Anzio, plus more effective air close support than was possible closer to the major Allied air bases, apparently permitted German air to influence Allied artillery losses to a greater extent than in any of the other US-German comparisons. This plot is also close to the estimated curve.

5.1b: The Anzio-Rapido battle was a typical struggle between two closely matched forces. Thus the plot would be expected to fall near the estimated curve, and it does.

5.2a: In the Rome campaign Allied air superiority was almost complete. Thus the "all causes" plot would be expected to fall considerably below the estimated "all causes" curve, and close to the estimated "artillery curve." Its location somewhat above the artillery curve suggests that German counterbattery fire took skillful advantage of the highly defensible terrain.

10a: The US Tenth Army artillery losses, against an enemy with no close air support capability, and with relatively crude and ineffective counterbattery capabilities, would be expected to plot considerably below the estimated "artillery" curve. It does.

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G-0a: The German artillery losses during the catastrophic month of August 1944 would be expected to represent typical "all cause" losses in intensive combat. This is confirmed by a plot very close to the "all causes" line.

G-1a: The German artillery losses during the much less intensive combat of September 1944 would also be expected to plot near the "all causes" line. The fact that it does not is not readily explicable. Possibly it was due to the fact that combat in that month was intensive for the Germans, and was intensively waged, while the Allies on all fronts were to some extent relaxing, and devoting their principal attention to preparations for coming offensives.

G-2a: The plot for average German artillery losses for 1943-1944 would be expected to plot near the "all causes" curve. It does.

4a: The plot of artillery losses of the German Fourth Army to all causes in November 1943, would be expected to plot near the estimated "all causes" line. It does.

4b: The plot of Fourth Army artillery losses to counterbattery would be expected to plot near the estimated "artillery" curve. Its location substantially above that line merely suggests that Soviet counterbattery fire that month was a little more effective than usual.

Artillery Loss Distribution Analysis

The Artillery Loss Distribution Analysis, shown on Figure 6, covers only World War II data, for reasons discussed below with respect to Israeli experience in the October War.

The purpose of this analysis is to ascertain the relative vulnerability of the three principal categories of World War II weapons (light, medium, and heavy) to hostile action. In the light of the variations in the different sets of data, the comparison considers not only the relationship of losses in these three categories to each other, but also the ratio of light to medium artillery losses, since most of the data is limited to these two categories. The ratios in each of the examples are weighted in terms of gun-days of exposure, normalized to the gun-days of the First Army in the Battle of the Bulge, which was the lowest total gun-days of our World War II examples. The comparisons were made only with respect to losses from all causes.

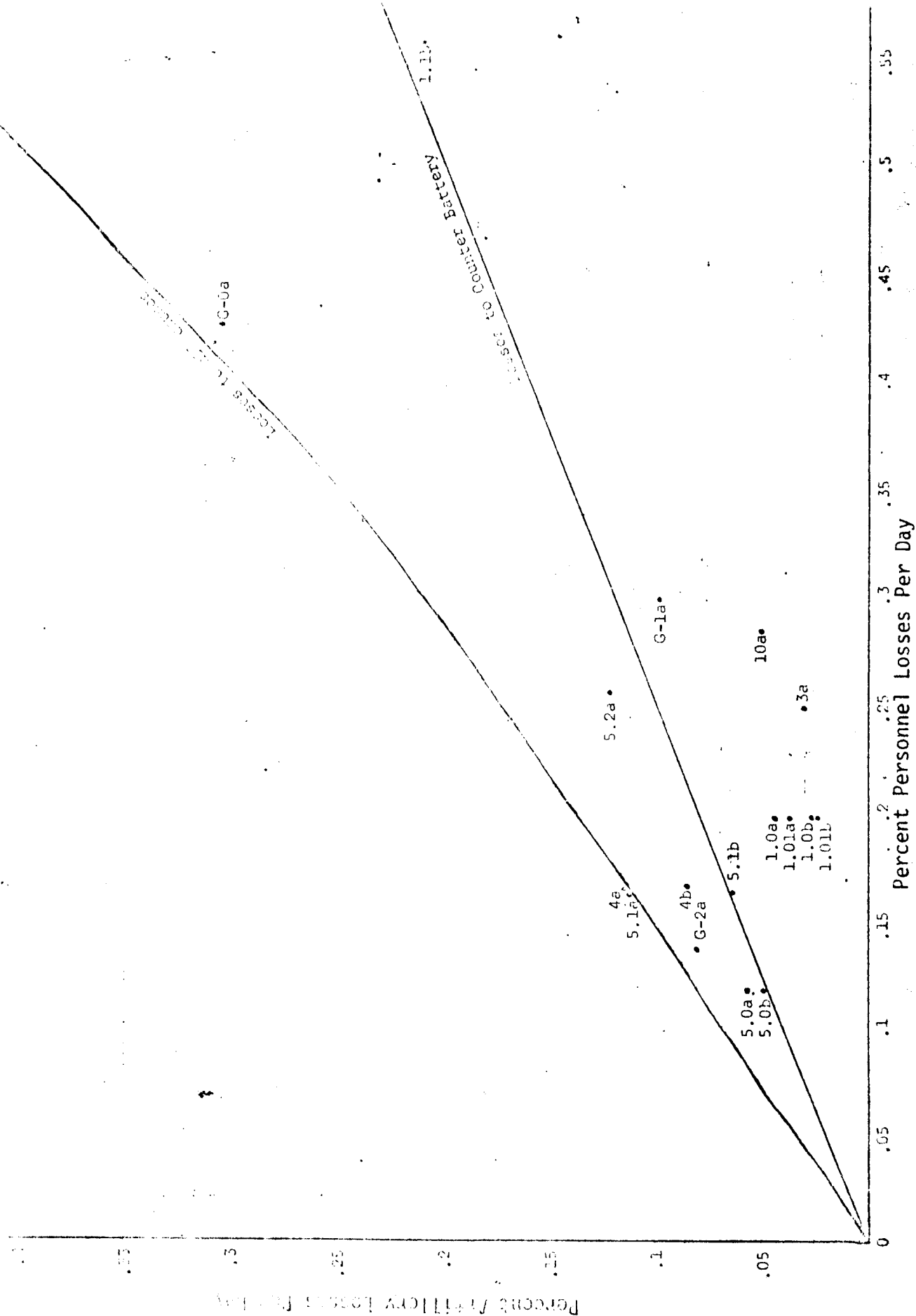
The most significant numbers in Figure 6 are those in the first two lines of Part B, showing the overall average comparisons of medium weapons to light weapons to heavy weapons losses, as follows:

light weapon losses, 2.2 times as great as heavy;
medium weapon losses, 1.9 times as great as heavy; and
light weapon losses, 1.2 times as great as medium.

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Figure 5

RELATIONSHIP OF ARTILLERY LOSSES TO PERSONNEL CASUALTIES
(World War II)



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Figure 6. ARTILLERY LOSS DISTRIBUTION ANALYSIS

Force	No.	Total Guns	Total Days	Total Guns Days/7110	Percent Loss Per Day				Loss Comparison			
					Light	Med	Heavy	ISM	Total	L/T	N/T	H/T
A. General												
US First Army, '44-'45	1.0a*	752	206	21.73	.049	.035	.013	.043	.037	1.32/25.68	0.95/20.64	0.35/7.61
	1.0b*				.025	.027	.013	.026	.023	-	-	-
	1.1a	648	11	1.00	.524	.341	-	.519	-	-	-	-
	1.1b				.223	.155	-	.210	-	-	-	-
US Third Army, '44	3a	893	92	(11.51)	-	-	-	-	.030	-	-	-
US Fifth Army, '43-'44	5.0a	292	370	15.23	.049	.081	-	.057	-	-	-	-
	5.0b				.026	.072	-	.029	-	-	-	-
	5.1a	304	68	2.90	.118	.097	-	.111	-	-	-	-
	5.1b				.065	.052	-	.063	-	-	-	-
	5.2a	324	28	1.27	.045	.034	-	.121	-	-	-	-
US Tenth Army, '44	10a	240	91	3.06	.063	.026	-	.050	-	-	-	-
Wehrmacht, Aug '44	G-0a	12,593	31	56.01	.354	.220	.183	.320	.305	1.16/64.97	0.72/40.73	0.60/33.61
Sep '44	G-1a	12,683	30	53.36	.109	.039	.023	.106	.097	1.12/59.76	1.02/54.23	0.24/12.65
'43-'44	G-2a	12,400	30	52.17	.081	.068	.062	.083	.080	1.01/52.69	1.10/57.39	0.78/40.43
German Fourth Army	4a	470	30	(1.98)	.092	(.148)	-	-	.113	(0.81/1.61)	-	-
B. Comparative Analysis by Weight Category												
				US and German	(Medium & Light losses/heavy Light & Heavy losses/medium Medium & Heavy losses/light							
				US Forces only (First Army only except for L/M)								
				German Wehrmacht only								
					2.19					1.83		1.00
					1.19					1.00		0.54
					1.00					0.84		0.46
					3.77					2.71		1.00
					1.40					1.00		0.37
					1.00					0.72		0.26
					2.05					1.76		1.00
					1.17					1.00		0.57
					1.00					0.86		0.49

*a - losses from all causes
b - losses from artillery

Figure 7

ESTIMATED OCTOBER WAR ARTILLERY LOSS DATA
October War, 1973

Israeli Army (By weight categories)	Estimated Total Mobilized Strengths	Estimated Field Forces Strengths	Losses	Per- cent	% / Day	Artillery Types	Strength	Approx. Ratio to Enemy	Combat Losses		Losses to Air		Losses to Artillery		Losses to other	
									No.	%	No.	%/day	No.	%/day	No.	%/day
Israeli Army	310,000	250,000	11,638	4.66	0.245	Hvy	93		5	5.38	2	0.095	2	0.095	1	0.048
						Med	155		7	4.52	3	0.102	3	0.102	1	0.034
						Lgt	372		16	4.30	7	0.099	7	0.099	2	0.028
						Total	620	0.30/1.00	28	4.52	12	0.102	12	0.102	4	0.034
						Med & Lgt	527		23	4.36	10	0.100	10	0.100	3	0.030
Israeli Army						SP	434		22	5.07	10	0.121	10	0.121	2	0.024
						Tow	186		6	3.23	2	0.057	2	0.057	2	0.057
						Total	620		28	4.52	12	0.102	12	0.102	4	0.034
Arab Armies	505,000	400,000	28,077	7.02	0.370	Hvy	308		11	3.57	5	0.086	5	0.086	1	0.017
						Med	514		32	6.23	13	0.133	13	0.133	6	0.062
						Lgt	1,233		97	7.93	43	0.185	43	0.185	11	0.047
						Total	2,055	3.31/1.00	138	6.72	61	0.156	61	0.156	18	0.046
						Med & Lgt	1,747		129	7.38	56	0.169	56	0.169	17	0.051

These comparisons reflect the fact that standard American and German doctrine for artillery deployment in World War II would, on the average, put the light artillery within 2-3,000 meters of the FEBA, medium artillery 3-5,000 meters behind the FEBA, and heavy artillery usually around 5,000 meters behind the FEBA.

To make such a comparison for Israeli forces in the October War would be meaningless, because of the Israeli response to the special circumstances of that war. The need to neutralize Arab SAM sites, in order to employ airpower in close support, caused the Israelis to move their long range heavy artillery as close to the front as they did their medium and light artillery. (For instance, either the first or second artillery unit that crossed to the east bank of the Suez Canal on 16 October, into a bridgehead less than 2,000 meters in depth, was a battalion of 175mm SP guns.) The presence of these heavy, long range guns just behind the FEBA naturally attracted Arab countermeasures, by both air and counterbattery. As a result, Israeli losses in heavy artillery were proportionally higher than in any other principal category.

General October War Analysis

Figure 7, Estimated Artillery Loss Data October War, 1973, is organized as is the World War II data for American Forces in Figure 1, and for German forces in Figure 3.

Figure 8, Relationship of October War and World War II Artillery Losses, is the same as Figure 5, for World War II, but with the Israeli and Arab data from Figure 7 superimposed on the World War II data. The additional symbols represent the following:

- I-0a: IDF, 19 days, overall artillery losses to all causes
- I-0b: IDF, 19 days, overall artillery losses to artillery
- I-1a: IDF, 19 days, medium and light artillery losses to all causes
- I-1b: IDF, 19 days, medium and light artillery losses to artillery
- I-2a: IDF, 19 days, towed artillery losses to all causes
- I-2b: IDF, 19 days, towed artillery losses to artillery
- I-3a: IDF, 19 days, self-propelled artillery losses to all causes
- I-3b: IDF, 19 days, self-propelled artillery losses to artillery
- A-0a: Arabs, 19 days, overall artillery losses to all causes
- A-0b: Arabs, 19 days, overall artillery losses to artillery
- A-1a: Arabs, 19 days, medium and light artillery losses to all causes
- A-1b: Arabs, 19 days, medium and light artillery losses to artillery

The relationship of these twelve separate plots to the World War II estimated curves for losses to all causes, and to artillery counterbattery, is extremely interesting.

I-0a: Overall artillery losses to all causes would be expected to plot substantially above the World War II curve, as a result of more effective modern air and counterbattery techniques, the higher vulnerability of self-propelled artillery, and the semi-desert, open terrain environment. This plot is indeed substantially higher than the World War II curve. For reasons shown below, this is undoubtedly due more to the nature of the terrain, and the self-propelled nature of most Israeli artillery, than to exceptional Arab skill in attacking artillery.

PERCENT PERSONNEL LOSSES IN CASES OF DISASTERS (Revised)

A-1a

A-0a

I-3a

I-1a

I-2a

I-3b

I-0a

I-1b

I-2b

10a

3a

1.0a

1.01a

1.0b

1.02a

5.0a

5.01a

5.1b

C-2a

5.1a

4b

A-0b

A-1b

1.1a

1.1b

Percent Personnel Losses Per Day

0

.05

.15

.25

.35

.4

.45

.5

.55

I-0b: This plot of losses to hostile artillery is very close to the World War II "artillery" curve, despite the high proportion of Israeli SP guns, only because Arab counterbattery was relatively ineffective overall, and because of Arab concentration of attention and efforts against Israeli SP artillery.

I-1a: The plot of all-causes losses of Israeli light and medium artillery is lower than that for overall losses simply because of high losses of Israeli heavy artillery, due to the IDF practice of pushing long range guns as close as possible to the FEBA to attack Arab SAM sites.

I-1b: The comments for I-0a and I-1a combine to explain this plot.

I-2a: The plot of losses of Israeli towed artillery is close to the "all causes" World War II curve mainly because Arab air action and ground action (other than counterbattery), offset the relatively light and relatively ineffective Arab artillery counterbattery fire against Israeli towed weapons.

I-2b: This low plot is a direct reflection of the light and ineffective Arab artillery counterbattery against Israeli towed weapons. 1.57

I-3a: This high plot is believed to reflect three things, in the following order of importance: (1) the much greater vulnerability of self-propelled artillery to hostile air and counterbattery than towed artillery; (2) Arab counterbattery concentration against Israeli self-propelled artillery, particularly long range guns; and (3) slightly greater vulnerability of artillery in desert or semi-desert terrain. The plot is 1.57 times the estimated losses of World War II artillery in an operation of comparable intensity; it is 1.89 times as high as the average of the other three plots of Israeli losses to all causes.

I-3b: The same comment applies as for I-3a, but to a lesser degree. The plot is 1.12 times the estimated losses in a World War II operation of comparable intensity; it is 1.35 times as high as the average of the other three plots of Israeli losses to artillery.

A-0a: This plot of losses to all causes is higher than World War II "all causes" losses reflects primarily the high effectiveness of Israeli airpower in attacks on artillery and, to a lesser degree, the slightly greater vulnerability of artillery in desert or semi-desert terrain.

A-0b: This plot of Arab artillery losses to Israeli counterbattery is remarkably close to the World War II "artillery" curve, lending confidence to the assumptions whereby gross losses were allocated by category of weapons lost and by causes, and also lending confidence to the analytical methodology here employed.

A-1a: Comment for A-0a is generally applicable.

A-1b: Comment for A-0b is generally applicable.

Conclusions

1. In the early wars of the 20th Century, towed artillery pieces were relatively invulnerable, and they were rarely severely damaged or destroyed except by very infrequent direct hits.
2. This relative invulnerability of towed artillery resulted in general lack of attention to the problems of artillery survivability through World War II.
3. The lack of effective hostile counter-artillery resources in the Korean and Vietnam Wars contributed to continued lack of attention to the problem of artillery survivability, although increasingly armies (particularly the US Army) were relying on self-propelled artillery pieces.
4. Estimated Israeli loss statistics of the October 1973 War suggest that because of size and characteristics, self-propelled artillery is more vulnerable to modern counter-artillery means than was towed artillery in that and previous wars; this greater historical physical vulnerability of self-propelled weapons is consistent with recent empirical testing by the US Army.
5. The increasing physical vulnerability of modern self-propelled artillery weapons is compounded by other modern combat developments, including:
 - a. Improved artillery counterbattery techniques and resources;
 - b. Improved accuracy of air-delivered munitions;
 - c. Increased lethality of modern artillery ammunition; and
 - d. Increased range of artillery and surface-to-surface missiles suitable for use against artillery.
6. Despite this greater vulnerability of self-propelled weapons, Israeli experience in the October War demonstrated that self-propelled artillery not only provides significant protection to cannoners but also that its inherent mobility permits continued effective operation under circumstances in which towed artillery crews would be forced to seek cover, and thus be unable to fire their weapons.
7. Paucity of available processed, compiled data on artillery survivability and vulnerability limits analysis and the formulation of reliable artillery loss experience tables or formulae.
8. Tentative analysis of the limited data available for this study indicates the following:
 - a. In "normal deployment, percent weapon losses by standard weight classification are in the following proportions:

<u>Light</u>	<u>Medium</u>	<u>Heavy</u>
2.2	1.8	1.0
1.2	1.0	
 - b. Towed artillery losses to hostile artillery (counterbattery) appear in general to vary directly with battle intensity

(as measured by percent personnel casualties per day), at a rate somewhat less than half of the percent personnel losses for units of army strength or greater;¹ this is a straight-line relationship, or close to it; the stronger or more effective the hostile artillery is, the steeper the slope of the curve;

- b. Towed artillery losses to all hostile anti-artillery means appears in general to vary directly with battle intensity at a rate about two-thirds of the percent personnel losses for units of army strength or greater; the curve rises slightly more rapidly in high intensity combat than in normal or low-intensity combat; the stronger or more effective the hostile anti-artillery means (primarily air and counterbattery), the steeper the slope of the curve;
- c. Self-propelled artillery losses appear to be generally consistent with towed losses, but at rates at least twice as great in comparison to battle intensity.

9. There are available in existing records of US and German forces in World War II, and US forces in the Korean and Vietnam Wars, unit records and reports that will permit the formulation of reliable artillery loss experience tables and formulae for those conflicts; these, with currently available, and probably improved, data from the Arab-Israeli Wars, will permit the formulation of reliable artillery loss experience tables and formulae for simulations of modern combat under current and foreseeable future conditions.

¹These loss rates are substantially lower than those for division and smaller units, see HERO's Combat Data Subscription Service, Vol I, No 1, p. 72.

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Recommendations

cial

1. That this report be circulated to all US Army and Department of Defense agencies concerned with artillery performance, artillery logistics, artillery design, and the simulation of artillery in current official models of combat.
2. That the work initiated in Phase One of this study be continued in Phase Two. A Concept Paper for Phase Two is annexed to this report.

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