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Historical Evaluation & Research Organization

HANDBOOK ON

GROUND FORCES ATTRITION IN MODERN WARFARE

SEPTEMBER 1986

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The contents of this handbook reflect the views and findings of the Historical Evaluation and Research Organization and are not to be construed as an official United States Government position unless so designated by authorized documents.

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INTRODUCTION

The purpose of this Handbook on Ground Forces Attrition in Modern Warfare is to provide military analysts with some background information that will help them understand and analyze current combat operations and project the possible outcomes of future combat. The basis for this treatment of attrition in modern warfare is historical analysis of combat.

The information in this handbook has been drawn together from a series of different studies and reports prepared by the Historical Evaluation and Research Organization (HERO) and by other organizations and individuals. Unfortunately, there has not yet been a systematic and comprehensive study of attrition in modern warfare, and the data had to be gleaned from the relatively few studies that have been done, often for purposes other than the study of attrition. Nevertheless, there has been sufficient historical analysis of attrition to provide a general understanding of this important phenomenon and how it relates to combat as a whole. Additional study may modify some factors and will give greater credibility to the findings, but the general relationships are likely to remain valid. At any rate, this handbook is the best compilation of historical analyses on attrition experience available at the present time.

Because of the way in which the data was collected and analyzed, most of it pertains to US Army experience and is presented according to US Army doctrine and terminology. Unless otherwise indicated in the text, the terms and concepts in this handbook are based on contemporary US Army doctrine. HERO has broadened these concepts and definitions of terms so that they can be applied universally to all modern armies, allowing for some local variation. The categorization of kinds of casualties, for example, tends to be the same for all armies, although varying emphases may be placed on treatment because of cultural differences or ideological biases.

The intent is to provide general terms, policies, and experiential data which can be applied with improved understanding by military analysts to specific situations.

In several instances, the handbook refers to concepts or findings from the Quantified Judgment Model (QJM). The concept of Relative Combat Effectiveness, for example, is important to an understanding of combat attrition but can be understood fully only in the context of the QJM. This handbook is not designed to provide a complete explanation of the QJM or to cover the full range of combat processes. This handbook provides enough explanation to allow use of the attrition information, but readers desiring complete information on the QJM, the concept of Relative Combat Effectiveness, or other aspects of modern combat which are explained or elucidated by the QJM are invited to obtain some of the other HERO publications and reports, particularly A Theory of Combat, a book by Trevor N. Dupuy scheduled for publication in Fall 1986, or his earlier book Numbers, Predictions and War, which is currently available from HERO Books.

Although the authors of this handbook believe that there has been insufficient analytical attention paid to attrition, much more historical analysis has been performed on personnel attrition than on materiel attrition, and that fact is reflected in this handbook. Chapter 6 on materiel attrition is the first synthesis of existing historical data into coherent form. Obviously, more work needs to be done on materiel attrition. Since the linkage between personnel attrition and materiel attrition has been established, it should be possible to provide much better treatment of materiel attrition than is now available.

Two omissions in this handbook should be noted briefly. One is that the Lanchester Equations or Laws are not discussed. The other is that there is no discussion of the impact of attrition on combat effectiveness.

The Lanchester Equations provide an analytical treatment of attrition; they are not historically based and do not necessarily relate well to historical experience. The Lanchester Equations and their contribution are covered extensively in the two publications by T.N. Dupuy mentioned earlier, and they are covered extensively in the military operations research literature. This handbook presents the results of historical analysis of attrition and does not touch on the relationship of these historical lessons to theoretical results. Efforts to relate the theory to the historical experience are underway and are beginning to bear fruit.

The other issue which is not addressed in this handbook is the impact of attrition on combat effectiveness. It is self-evident that reduced strength impairs combat effectiveness, but the extent and nature of this loss of effectiveness is not clear. Some early work on the effect of strength losses on combat effectiveness in World War II was done in the 1950s, notably by Dorothy Clark.* Little systematic work has been performed on this matter after that. There is, for example, no comprehensive historical analysis to either support or refute the widespread assumption that there is a "breakpoint" in strength below which a unit loses cohesion and becomes completely ineffective. More work needs to be done on this point.

The Soviet system is not addressed *per se*. Information on Soviet attrition experience has not been available readily, but there is sufficient information to draw general conclusions about the Soviet attrition process. In general, the Soviet experience is comparable to that of other modern armies, and the Soviet system in reacting to attrition is similar to those of other modern armies. The Soviet armed forces, like the United States Army, do place stress on prompt and effective medical treatment of casualties. Reports that the Soviets are callous and sacrifice lives carelessly have little validity. It must be recognized, however, that all armies, including the Soviets, have at certain times adopted tactics which produced greater than normal casualties. The French Army, for example, at the outbreak of World War I, used tactics which produced huge casualties among

* Dorothy K. Clark, *Casualties as a Measure of the Loss of Combat Effectiveness of an Infantry Battalion*. Technical Memorandum ORO-T-289. (Chevy Chase, Md.: Operations Research Office of the Johns Hopkins University, 1954).

their own troops until the inevitable reactions of troops and commanders forced modifications.

This handbook is a unique product. It is the first time that the available historical facts dealing with attrition have been compiled into a single comprehensive document. As such, it will have value for analysts dealing with current military problems. It will serve also as a useful basis for updating as additional work is performed and understanding of attrition in modern warfare is improved.

Chapter 1

FUNDAMENTALS OF ATTRITION

The purpose of this chapter is to introduce the concept, significance, and terminology of attrition so that the later chapters will be easier to understand.

Attrition is a reduction in the number of personnel, weapons, and equipment in a military unit, organization, or force.

Significance of Attrition

Others things being equal, victory in battle is a function of the numbers of troops and weapons on each side. While leadership, morale, tactics, and chance do influence battle outcome, the numbers of troops and the numbers and types of weapons also influence battle outcome. Each commander would like, therefore, to have as numerous a force as possible throughout the battle.

Force strength is the number of personnel and weapons in a force. Change in force strength is a function of the balance between attrition and augmentation. If attrition exceeds augmentation, force strength is reduced. If augmentation exceeds attrition, force strength is increased. If attrition equals augmentation, force strength is maintained at a constant level.

It is necessary, therefore, for commanders to attempt to minimize attrition in order to maximize force strength.

It is useful also to be able to forecast attrition accurately in order to provide for the proper numbers and types of augmentation in the planning process.

Augmentation has three components, as follows: fillers; replacements; and reinforcements. Fillers are individuals who bring units up from peacetime to wartime strength upon mobilization. Replacements are individuals who offset losses to maintain the original strength of a unit. It is also possible to replace entire units to maintain the original strength of a force. Reinforcements are additional individuals or units over and above the original strength of a force. The commander has little influence over the replacements or reinforcements he will receive, except to the extent that he can obtain more personnel, equipment, and units from his higher commander or can commit his own reserve. The application of additional force is one of the most important tools available to any commander to influence battle outcome.

Attrition is the difference between losses and returns to duty. Returns to duty are personnel who have been counted as a loss and then report back to their units. They are included as a component of attrition instead of as a kind of augmentation. The number and proportion of losses which are returned to duty is very important in maintaining force strength. The commander normally has some control over returns to duty by the actions he takes to assure medical care for his people and maintenance for his damaged equipment. A combat commander, however, usually must depend on higher level organizations to provide most of this medical and maintenance support.

The primary factor in attrition is losses. The number of losses caused by enemy action can be influenced by a commander only partially. He can minimize his losses by clever tactics, good strategy, and good leadership, but the opposing commander and troops also have a great influence over the amount and kind of losses too. Combat implies losses, and except for extraordinary circumstances, losses will occur in battle.

Kinds of Attrition

There are two basic kinds of attrition: personnel and materiel.

Personnel attrition results from the killing, wounding, capture, injury, or illness of military personnel or civilian employees.

Materiel attrition results from the disabling or destruction of weapons, equipment, and supplies.

The causes and treatment of attrition have many similarities for both personnel and materiel, but they commonly are treated as separate topics. This is because it is perceived as proper to treat the killing and wounding of people as being an entirely different matter than the loss of equipment. In this handbook, we shall follow the convention by treating the two separately, while pointing out the similarities and relationships when appropriate.

Causes of Attrition

Attrition has three major causes: enemy action; accidents; and illness or wearout.

Enemy action causes attrition mostly by hitting people and equipment with bullets or fragments (both large and small) from artillery or mortar shells, aerial bombs, or missiles. In addition, it is possible to damage both people and equipment by bringing them into contact with fire, toxic chemicals, or germs. It will be possible in the future to damage people and equipment with laser beams and particle beams. Most attrition in modern war occurs because of enemy action.

Accidents also cause attrition. The proximate cause of accidents usually is carelessness and violations of good health or safety practices. Accidents occur in armed forces in peacetime because people are using dangerous weapons and equipment. During wartime there are more accidents because the operating tempo is increased, matters have to be accomplished urgently, people are tense, and safety rules are relaxed. Accidental attrition is an important consideration in maintaining the strength of a force.

Illness or wearout causes attrition when people get sick and equipment wears out. This cause of attrition impacts primarily on people. For personnel, disease was the single most important cause of attrition until about 80 years ago. It is still a very important cause of personnel attrition, particularly in environments which are inherently hostile to humans.

The Attrition Cycle

Attrition is a process which occurs in a cyclic manner. Since commanders are concerned with replacement of losses as well as obtaining additional force strength, it is usual to provide for treatment of personnel and repair of equipment at intermediate points in the replacement stream. As shown in

Figure 1, the general principles of this attrition cycle apply both to personnel and materiel.

Figure 1

The Attrition Cycle

	Personnel	Materiel
Complete Loss:	No recovery	Salvage for parts
Partial Loss:		
Combat Zone:	Immediate treatment & return to unit, or evacuation	Repair & return to unit, or evacuation
Theater Support Zone:	Treatment & return to replacement pipeline, or evacuation	Repair and return to depot stocks, or evacuation
Zone of the Interior (ZI):	Treatment & return to ZI duty, or discharge from the service.	Repair and return to ZI stocks

The key distinction among the levels at which the person is declared fit for duty or a piece of equipment is declared serviceable is the speed and certainty of return to the original unit suffering the loss. Personnel and equipment returning to duty from treatment in the combat zone will almost certainly return to their original unit and rather quickly. Personnel or equipment returning to duty from the Theater Support Zone will probably not return to their original unit but will serve with some other unit in the theater. Personnel or equipment treated in the Zone of the Interior (ZI) will not return to combat duty soon, if ever, and then as a new replacement.

Personnel Loss Categories

There are two basic categories of personnel losses: (1) Battle Casualties and (2) Disease and Non-Battle Injuries (DNBI).

Battle Casualties are caused by enemy action. The number and type of battle casualties is a function of enemy force strength, friendly force strength, environmental and operational factors of the combat, and the human factors, such as leadership, morale, and luck. Commanders can influence to some degree the rate, number, and kinds of battle casualties by the way in which they lead their units. There are three kinds of battle casualties:

Killed in Action (KIA). Personnel who are killed outright or die of wounds on the battlefield before receiving any medical treatment are listed as KIA. KIA require effort to recover, identify, record, and provide proper burial to the deceased remains. This work is the responsibility of the graves registration system, but many other personnel will assist in this function, particularly in the recovery phase. Most fighting forces place great importance on the proper and respectful treatment of their own dead. This is true of the United States Armed Forces.

Wounded in Action (WIA). Personnel who are wounded and enter into the medical system while still alive are classified as WIA even though they may have died of wounds (DOW) some time thereafter. WIA personnel require a great deal of effort on the part of the military medical system. Great stress is placed on the prompt and effective treatment of wounds for two reasons. First, early and effective treatment provides a greater number of returns to duty. Second, obvious excellence in treatment of wounds helps morale and increases the willingness of troops to enter combat. Most fighting forces place great stress on good treatment of the WIA. There are four possible dispositions for WIA:

1. Return to Duty
2. Died of Wounds
3. Transfer to another medical facility
4. Discharge from the armed forces

Captured-Missing in Action (CMIA). Personnel who become separated from their units during combat are listed as CMIA. Some of these personnel are captured by the enemy and become prisoners of war (POW), at least temporarily. Some of these POW escape and return to duty. Some of the CMIA are still under friendly control but are not with the unit responsible for accounting for them; these MIA personnel often are returned to duty. Some CMIA are neither captured nor separated from their unit but, in fact, are dead. This situation occurs when a person is killed or dies of wounds under circumstances unknown to other surviving members of his unit. Sometimes wounded CMIA personnel are recovered and placed into the medical treatment system. There are five possible dispositions for CMIA:

1. Return to Duty
2. Dead
3. Wounded
4. Prisoner of War
5. Missing

Non-Battle Casualties are called Disease and Non-Battle Injuries (DNBI). The three major categories are disease, mental illness, and injuries.

Disease is illness caused by bacteria, viruses, parasites, or other organisms. Patients may be mildly debilitated, severely debilitated, or killed by disease. In the past disease has been a major factor in maintenance of strength and health of armies, but modern medical systems have relegated disease to a relatively minor factor, at least for modern armies.

Mental Illness is a form of disease caused by emotional or psychological traumas. The reaction of soldiers to the stresses of combat can cause mental illness. The name has varied from "shellshock" in World War I, to "battle fatigue" in World War II, to "Vietnam stress syndrome" in Vietnam, but the causes and effects remain largely the same. Mental illness usually is considered to be related to poor morale and lack of conviction and may be considered an extreme form of these general problems. Mental illness and its opposite, mental toughness, are important factors in current non-conventional warfare, such as insurgency. Mental illness is seldom fatal initially, but it can lead to the inability of the victim to continue performing effectively in a combat unit or in the theater of operations.

Injuries are caused by accidents. In general, these have the same effects as WIA and are treated much the same. Some people die of their injuries. The injured are treated and either returned to duty in the theater or returned to the Zone of the Interior for further treatment and then either returned to duty there or discharged from the service.

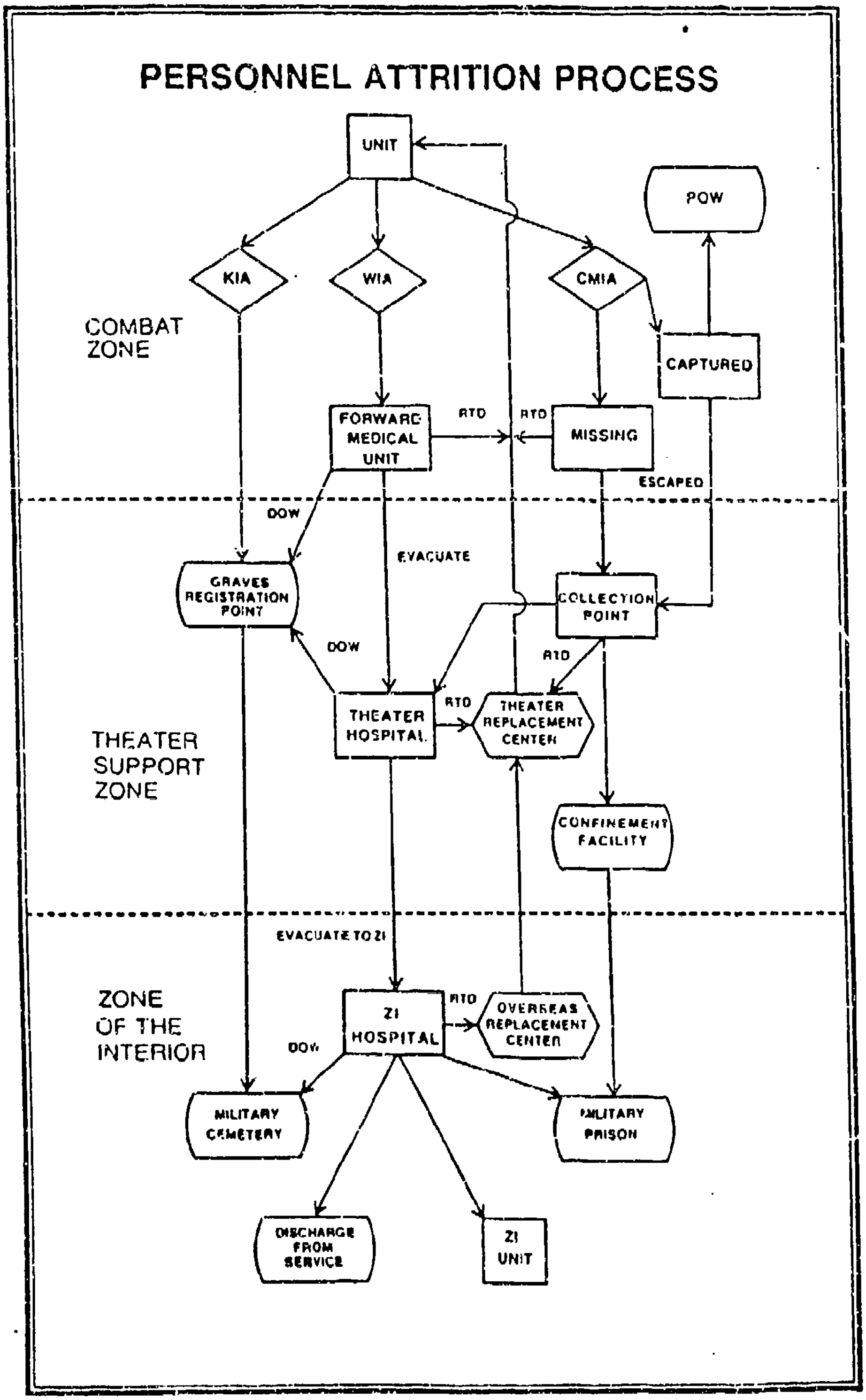
The Personnel Attrition Process

A generalized, schematic diagram of the attrition process for personnel is shown in Figure 2. The three areas of interest are the Combat Zone, the Theater Support Zone, and the Zone of the Interior. For the United States, the Zone of the Interior is the Continental United States, or CONUS. For the Soviet Union, the Zone of the Interior is the Soviet Union itself. The Theater of Operations may be divided into several geographical areas or commands, depending on the circumstances. Only one Theater Support Zone is shown in this diagram for simplicity's sake. The Combat Zone is generally considered to be forward of the corps rear boundary, but this also will vary according to circumstances. These three basic zones will exist in all wartime situations, but there will be as many variations as there are wars.

The three basic categories of casualties are processed differently. Personnel who are killed in action, die of wounds, or die from injuries or disease are collected at various graves registration points for identification and subsequent burial in a temporary or permanent cemetery.

Personnel formerly in the CMIA category are gathered at designated collection points for processing. Depending on their condition, they are placed in the medical treatment system or returned to duty in the replacement system. Many of those who have strayed from their units accidentally return to their original units directly. Those who desert or go AWOL are collected and either returned to their units for disciplinary action or, if the case is serious, held in a confinement facility awaiting trial. Those convicted of crimes are sent to military prisons.

Figure 2



The most complicated process involves those personnel who require medical treatment. These are the wounded in action, injured, and sick, all indicated in the diagram as WIA. Initial treatment is likely to be at a battalion or regimental aid station. A decision is made at each treatment facility to treat and return to duty or evacuate the patient to another, more capable, medical facility. While the diagram shows only one forward medical unit in the Combat Zone, in reality there would be several: battalion or regimental aid stations; division medical battalion; evacuation hospital; forward surgical hospital; and field hospital. Personnel treated at medical facilities in the Combat Zone generally return directly to their original unit when they have been declared fit for duty.

Once the patient is moved to a theater level hospital, he is unlikely to be returned directly to his original unit upon release. Patients released from theater level hospitals more often are reassigned to the theater personnel replacement system for further reassignment to units needing certain skills and grades.

Once the patient is evacuated to a hospital in the Zone of the Interior (ZI), the chances of his returning to his original unit are even less than from a theater hospital. Patients released from ZI hospitals often are reassigned to ZI units. Sometimes they are reassigned back into the oversea theater replacement pipeline. Sometimes they are discharged from the service or placed on limited duty.

The tendency, therefore, is to treat people as near to the original combat unit as possible in order to maximize the number of returns to duty and to help preserve cohesion by having the wounded, injured, or sick person rejoin the original unit.

Theater Evacuation Policy

One particularly important consideration with respect to attrition is the policy set for evacuation of patients or damaged equipment items from the theater of operations to the Zone of the Interior. While this is important for materiel, it is especially important for personnel.

The personnel theater evacuation policy is a statement of the maximum number of days that a patient will be treated in a medical facility in the theater of operations.

When a patient who is wounded, sick, or injured is admitted to a theater of operations medical facility an estimate is made of the number of days of treatment required to cure the patient so he or she can return to duty. If the projected length of treatment for the patient is less than the theater evacuation policy, the patient will be retained in the theater for treatment. If the projected length of treatment for the patient is greater than theater evacuation policy, the patient will be given enough treatment to stablize his or her condition and then transported to the ZI for additional treatment until returned to duty.

The consequences of the evacuation policy are very important. The fewer the theater treatment days allowed by the policy, the higher the proportion of patients who will be sent to the ZI, the fewer the medical resources which will be needed in the theater, and the fewer recovered patients who will be returned to duty in the theater. The greater the days in the evacuation policy, the smaller the proportion of patients evacuated, the greater the medical resources required in the theater, and the greater the number of patients returned to duty in the theater. Medical authorities generally prefer a short evacuation policy because they want to treat the patients in the better hospitals in the ZI. Troop commanders and personnel officers prefer a long evacuation policy because they want to retain as many recovered patients for their own strength as possible. So, there is continuous tension regarding this policy.

In practice, the policy is often set on the basis of categories of disease rather than on number of days of treatment. All burn wounds, for example, might be sent to a special hospital in the ZI regardless of projected length of treatment. All malaria patients might be retained in the theater for treatment.

Improved methods of evacuation have tended to shorten the times of theater evacuation policies. Helicopters have made it easier than before to move wounded soldiers directly to base hospitals rather than going through unit aid stations or even field hospitals. Jet aircraft have made it possible to evacuate wounded soldiers from the theater more easily than before. The short times of jet travel and the ease of moving the patient directly from battlefield to airfield make it very convenient to do this. In Vietnam US wounded personnel were often evacuated directly from field hospitals to hospitals in the United States or Japan for relatively minor wounds or injuries.

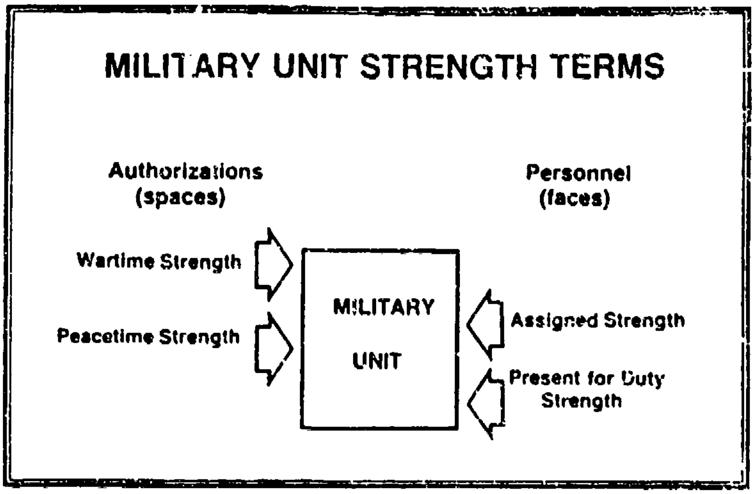
From the viewpoint of attrition, the key point is that the probability that a wounded or injured soldier will return to the theater of operations is reduced significantly if the soldier is evacuated from the theater. This increases personnel turnover and lowers the experience level of the theater forces, particularly of the combat units which suffer most of the casualties. In this respect, evidence of the theater evacuation policy can be useful in estimating strength and experience levels for these forces.

Personnel Strength Terminology

Because attrition is a process causing a change in strength, it is useful to understand the terminology used to describe and measure personnel strength. There are many terms, all with precise meanings, but often used interchangeably and incorrectly.

Strength is the number of either personnel or personnel authorizations in a military unit, organization, or force. The difference between personnel (faces) and authorizations for personnel (spaces) is very important. Authorizations, or billets, are established by higher headquarters to describe the numbers, skills, and grades of personnel that the unit should have to accomplish its mission. The personnel system tries to fill each authorized space with the right kind of person, but this is seldom achieved in practice. Thus, there are a variety of terms to describe the situation that does occur. Figure 3 is a schematic diagram of a military unit.

Figure 3



Wartime Strength and Peacetime Strength, along with such terms as "full strength," "TOE* strength," and "authorized strength" are authorization terms referring to the number of spaces a unit is allowed to fill with personnel. All units have a full wartime strength at which the unit is designed to operate in combat. In peacetime many units in most armed forces are authorized less than wartime strength as an economy measure. Manpower authorizations can include military personnel and civilian personnel. The US Army has units which include both military and civilian personnel; most of these units are rear area service support units. Authorization terms are not good guides to the number of personnel in a unit because most personnel systems fail to fill all of the authorized spaces, to say nothing about filling them with proper grades and skills.

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*This refers to the Table of Organization and Equipment (TOE), which is the document used in the US Army to establish authorizations for numbered units intended to fight as part of the Army-in-the-field. The US Army also has Table of Distribution and Allowance (TDA) documents for stationary support units.

There are two basic descriptors of personnel strength.

Assigned Strength of a unit is the number of personnel shown on the personnel records of the unit as belonging to the unit. This does not mean that all of the people are actually with the unit. Some personnel are assigned but are away on temporary duty; some are at school; some have left the unit physically for a new assignment but are still on the books; and some have been assigned to the unit but have not yet joined. Other personnel are sick in the hospital or in their quarters. Still others are away on leave or on pass. Assigned strength is not a good indicator of fighting strength.

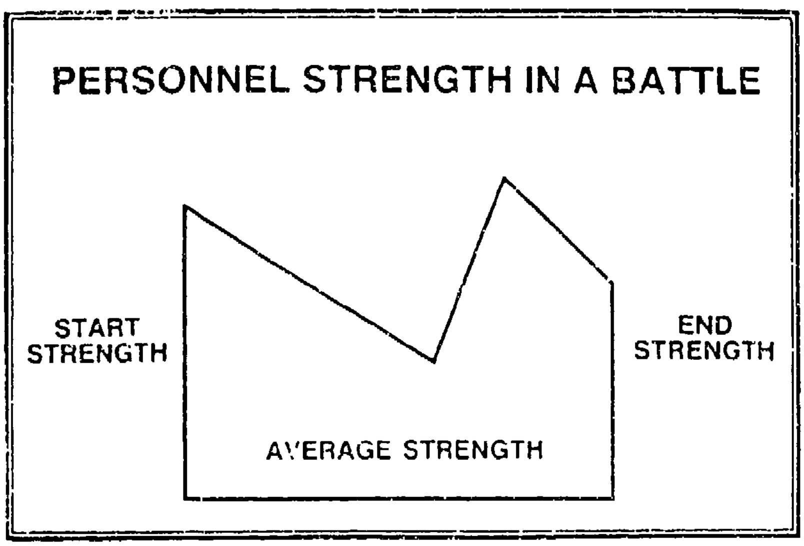
Present for Duty Strength is the number of personnel who are actually with the unit ready to fight or work. This, of course, is the important strength as far as combat power is concerned and is the basis for estimates of attrition. This is the "effective strength" of the unit.

Non-Available Personnel. A basic characteristic of any personnel system is that there are large numbers of personnel who simply are not available for duty. These are the people that are always going or coming but never seem to arrive. These include personnel on leave, moving from one unit to another, in the hospital, in training camps or schools, in prisons, or simply missing. There are two basic ways to manage these non-available personnel. One way is to expand the authorization for the unit to take into account the fact that soldiers are authorized leave and get sick, so that there will be enough people present for duty to get the necessary work done. This method is used for rear area units, administrative headquarters, and for civilian personnel. The other method is to create separate authorizations for these non-available personnel as individuals not assigned to units. The US Armed Forces uses separate individuals accounts for military personnel, transients, trainees, prisoners, patients, students, and holdees. In mobilization an account would be established also for replacements. These authorizations for individuals are designed to assure that the units designed to operate in the combat theater are at their authorized strengths.

Kinds of Strength. Another set of terminology for strength data has to do with the time and method of measurement. A strength figure is valid for a particular point in time. The assigned strength and present for duty strength are measured and reported each day. When strength figures are reported, they are often reported as of the last day of a particular month or year. These strengths are properly referred to as "end-month strength" or "end-fiscal year strength." In military jargon this is sometimes shortened to "end strength."

The strength of a unit or a force in a battle or engagement may be described using several different descriptors. Figure 4 shows a schematic of the relationship of some of these terms.

Figure 4



The average strength is the area under the curve. It is possible to compute a strength descriptor which is the average of the start strength and end strength, but this will be the same as the average strength only if strength function is linear from start to finish. It is possible also to calculate average daily strengths, which provides a more disaggregated descriptor than average strength. Another measure sometimes found in historical literature is total strength on the battlefield, which would be the cumulative sum of the strengths of all units which arrived on the battlefield, whether they left or stayed. Each of the various strength descriptors is valid provided the analyst knows which is being used and what it means. Figure 5 provides definitions of personnel strength terms for a battle or engagment.

Figure 5

Personnel Strength Terms

Start Strength:	strength on the day before a battle or engagement or at the beginning of the first day of a battle.
End Strength:	strength at the end of the last day of a battle or on the day after the battle.
Daily Strength:	start or end strength on a particular day.
Average Daily Strength:	one half the sum of start and end strengths for a particular day.
Total Strength:	the cumulative number of personnel in the battle from start point to end point.
Average Strength:	the sum of the daily strengths divided by the number of days in the battle.

Materiel Attrition Concepts

The basic concepts of materiel attrition are generally similar to those for personnel. There is, however, one basic difference.

The difference is that personnel come in two basic models with some flexibility for application, but materiel comes in a bewildering variety of makes and models and years of manufacture, often with no flexibility of application. A piece of equipment can be used only for the purposes for which it is designed. A bulldozer cannot shoot a projectile, and a cannon cannot move earth. While personnel do come with varying degrees of training and experience, they can be retrained and can be applied to a fairly wide range of jobs (with obvious limitations). The significance of this is that the materiel supply system must provide an exact or nearly exact replacement for the lost item.

The meaning of the word "exact" applies in particular to the make and model of the item being replaced. Modern weapons and combat support equipment are very complicated and require a great many repair parts, trained mechanics, and often special tools to keep operational. There are obvious limits to the requirement for exact replacement of materiel, but there are obvious demands as well. It would not do to replace a 130mm howitzer with a 75mm howitzer; an artillery battery could not fire efficiently with different guns. It would be possible to have different tanks operating in the same company, but it would complicate combat operations. It certainly is possible to have different makes and models of trucks in a transport company, but it does make it harder to maintain and repair the trucks because of the necessity for multiple sets of parts and tools.

The complications of make and model are particularly acute for support equipment, such as generators and air compressors. These relatively small items are prevalent in any modern army and can occur in a multitude of sizes, makes, models, and years of manufacture. As a result, they are very difficult to maintain. Engineer equipment is also complicated. During the Korean War era, the US Army had two different groups of makes and models for engineer equipment. One group was deployed to the Pacific; the other group to Europe. This was done to simplify parts supply and maintenance. The significance of make and model preference is that it complicates resupply. This is true of most modern armies. It is less true of unsophisticated guerrilla forces, but it is always a consideration.

There are three kinds of materiel: consumables; equipment; and repair parts.

Consumables are consumed in use. These include ammunition, food, water, POL, and numerous sundry items. Consumables do require care in storage, and they do require some maintenance to keep them in good shape for eventual use. Ammunition, for example, needs to be rotated and turned over every once in awhile. However, consumables which are damaged or destroyed generally are not repairable and cannot readily be put back into usable shape. Losses of consumables, therefore, must be replaced by new stocks.

Equipment consists of the major end items which allow the military force to operate. These include the following: weapons; combat vehicles; aircraft; helicopters; trucks; radios; computers; furniture; tentage; and personal items, such as helmets, boots, and uniforms. Equipment which has been damaged often can be repaired, and it generally is faster and cheaper to repair damaged equipment than it is to replace it. Every modern army, therefore, has a system for maintenance and repair of equipment end items. This system often is elaborate and includes large numbers of trained personnel. Even unsophisticated forces make some provision for repair of damaged equipment. The primary emphasis during the treatment of materiel attrition will be on equipment end items and on the way in which the maintenance system mitigates losses due to enemy action or to accident.

Repair parts are an essential element of the maintenance and repair system. Unless the correct part -- and only the correct part -- is available, the end item cannot be repaired. There is some relief to be obtained from this demanding requirement through manufacture of parts in the field, but manufacturing parts to order is itself a demanding and difficult process. It usually is easier to provide the correct part.

The Equipment Maintenance System consists basically of four main elements: unit maintenance; field maintenance; theater depot maintenance; and ZI depot or factory maintenance. There will be numerous variations within this basic framework to account for local conditions and traditions, but these four elements occur in every system.

Unit maintenance is the basic element of any equipment maintenance system, even in units without a formal maintenance section or trained mechanics. The first echelon of maintenance is performed by the operator or crew of the equipment. This consists of cleaning the item, adjusting it, and making certain that it has sufficient oil, fuel, and other required supplies. Operator maintenance exists in all military forces, even if it consists only of cleaning and oiling a rifle and washing mud or sand off of ammunition. Some operator maintenance is quite complicated and demanding, such as changing a track on a tank.

Some battalion-sized or larger units have their own maintenance section, consisting of a few mechanics and some relatively uncomplicated tools. These personnel perform the second echelon of maintenance, which consists of making simple adjustments and replacing some parts, such as fan belts or fuel filters. The operator or crew normally assist the mechanic when this work is being performed.

Both forms of unit maintenance are designed to cope with normal wear and tear on equipment rather than damage caused by enemy action or by accidents. Although the capabilities of the operators and the unit mechanics are often greater than they are designed to be, most battle damage repair requires the services of skilled mechanics and special equipment found in specialized maintenance units.

Field Maintenance is performed by maintenance units in the field in close proximity to the combat units. These units perform the third echelon of maintenance, which is repair and replacement of major assemblies of the equipment. Field maintenance is capable of performing extraordinary feats to keep equipment operational. It is at this level that repair of damage from enemy action and from accidents starts. From the unit viewpoint the difference between unit and field maintenance is that the unit loses the piece of equipment, at least temporarily, when it goes into field maintenance. That is, the equipment is transferred to the maintenance company, but it will be returned to the original unit when it is repaired.

Sometimes the initial inspection of an equipment item at the field maintenance unit indicates that the equipment will be in the shop for an extended period of time. In this case, it is possible sometimes to issue the unit a replacement item immediately from stocks held for this purpose by the maintenance unit. The "maintenance float" stocks are designed to keep the units at their authorized strength in important equipment items while the damage is being repaired. Needless to say, in combat the maintenance float stocks are exhausted quickly, since they are basically designed to cope with peacetime losses.

At the field maintenance unit a piece of equipment can be sent in any of four directions. It can be repaired and returned to the unit. It can be repaired and put into maintenance float to replace an item which previously was sent to the unit. It can be deemed unrepairable and scrapped. It can be sent to a higher level maintenance unit for repairs which exceed the capability of the field maintenance unit.

Depot maintenance is the highest level of military maintenance. Depots are found in the theater of operations and in the ZI. Depots in the theater of operations may have less capability than do those in the ZI, but both have the capability to rebuild a damaged piece of equipment, turning out what is in effect a new item. The depot maintenance capability includes replacement of major assemblies and the repair of subassemblies. Field maintenance can replace a vehicle engine; depot maintenance can rebuild the engine. The skills and tools and facilities at depots are the most sophisticated in the military forces.

The major difference between field and depot maintenance, as far as the losing unit is concerned, is the identity of the piece of equipment. The unit is quite likely to get its original equipment back from field maintenance, or at least one like it from the float. Once the equipment item enters the depot maintenance level, however, the connection with the unit is broken, and the unit must draw a new (or rebuilt) item from the supply system. Commanders in combat prefer to have repair or maintenance work done by their supporting field maintenance unit, because normally this reduces the time required to get a working piece of equipment to replace the damaged item.

Depot level maintenance in the Zone of the Interior is sometimes carried out by the factories which built the equipment in the first place. This is often referred to as overhaul or rebuild.

<u>Recovery</u>. An important element in the equipment maintenance system is recovery of damaged and destroyed equipment. While some damaged equipment can be carried off the battlefield or leave under its own power, some critical items have to be hauled off by a recovery vehicle. This recovery

process is critically important to the success of the maintenance effort. The Israeli Army has been particularly effective in pulling damaged tanks off the battlefield to nearby field maintenance units where they are repaired on the spot. If the item is not recovered, it may fall into enemy hands or otherwise be lost and prevented from being repaired. Thus, it is important to provide for prompt movement of immobile damaged equipment to the shops.

The Materiel Attrition Process

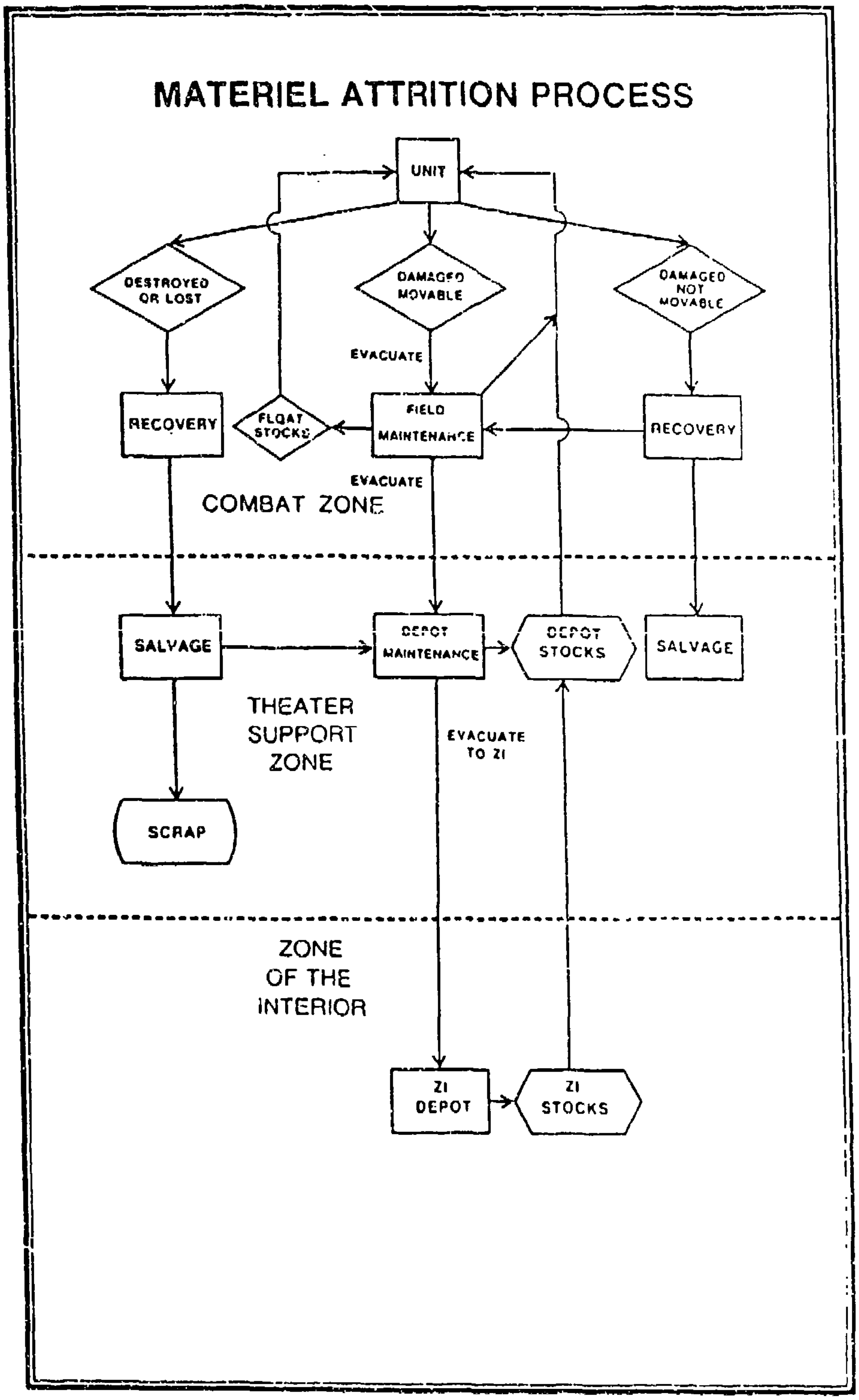
A generalized, schematic diagram of the Materiel Attrition Process is shown in Figure 6. This is very similar to the diagram for the personnel attrition process in Figure 2.

The three basic zones -- combat, theater support, and interior -- still apply. The general flow of destroyed and damaged equipment is similar to the flow of sick and wounded personnel. There are some relatively minor differences.

One difference is in the utility of equipment which is destroyed or damaged beyond repair as a source of repair parts for the maintenance system. It is customary in well-organized armed forces to recover even destroyed equipment from the battlefield and move it to salvage facilities where the best use is made of the equipment. Parts are sent to the maintenance facilities, and the unusable portions are scrapped.

Another difference is the emphasis on recovery as a separate function. Battlefield recovery of wounded personnel and subsequent movement within the medical treatment system is obvious. Battlefield recovery of damaged and, particularly, destroyed equipment is not so obvious and usually requires

Figure 6



MATERIEL ATTRITION PROCESS
UNIT
DESTROYED OR LOST
DAMAGED MOVABLE
DAMAGED NOT MOVABLE
EVACUATE
RECOVERY
FLOAT STOCKS
FIELD MAINTENANCE
RECOVERY
EVACUATE
COMBAT ZONE
SALVAGE
DEPOT MAINTENANCE
DEPOT STOCKS
SALVAGE
THEATER SUPPORT ZONE
EVACUATE TO ZI
SCRAP
ZONE OF THE INTERIOR
ZI DEPOT
ZI STOCKS

separate identification as a service support sub-system.

The final difference is in the application of the theater evacuation policy. The extent to which damaged equipment is evacuated from the Theater of Operations to the ZI is highly circumstantial. Movements of patients to the ZI is a tractable problem, particularly with modern aircraft. Movement of equipment is not so easy. Some high value, low bulk items such as electronic devices or radios, can be evacuated easily, often by air. Bulky and heavy items, such as trucks and tanks, are less easy to evacuate, despite the possible availability of empty ships or railway cars which otherwise would be travelling empty. Some items might be evacuated; others might be retained in the theater support zone for repair. This will depend on the available transportation and the existence or absence of maintenance facilities in particular locations. A theater evacuation system, however, is an integral element of the materiel attrition process and can be an important factor in establishing the effectiveness of the process in a particular war.

Kinds of Attrition Rates

Attrition can be understood best by referring to rates. The actual number of casualties, while important for a single combat event, does not permit aggregation or comparison among many combat events. Accordingly, it is necessary to calculate attrition rates when performing analyses of attrition. In this handbook we use the term "casualty rate" when referring to losses of personnel and "loss rate" when referring to losses of materiel.

There are several different kinds of casualty rates, and it is important to know which kind of rate is being used in a particular analysis or study. Comparing data with two different kinds of rates can give misleading results.

The three important dimensions of attrition rates are the duration for which the rate is calculated, the size of the unit, and the level of combat.

A rate is the number of casualties or losses divided by the time period, or duration, for which the rate is being calculated. The most common attrition rate is the daily rate. Sometimes the monthly rate is used. The annual rate is found in summaries of wars. Daily rates cannot be compared to annual rates.

Attrition rates usually are expressed as a proportion of the strength of a unit or force which is lost per time period. Sometimes the rates are stated as a number of casualties or losses per 1,000 per time period. The most common form of rate is percentage of the strength per time period. In this handbook, attrition rates are stated in terms of percentages.

The size of the unit involved is also important. As will be demonstrated later, the casualty rate is inversely proportional to the size of the unit. Small units have high casualty rates, and large units have low casualty rates. It is necessary to specify in each instance the organizational level, such as battalion or division for which the rate has been calculated. It is permissible to compare rates only if they are for the same general size of units.

Level of combat is particularly important. Figure 7 shows the Hierarchy of Combat and some of the characteristics of each level.

Figure 7

Hierarchy of Combat

Level of Combat	Duration	Units Involved	Common Thread
War	Months-Years	National Forces	National Goals
Campaign	Months	Army Groups or Field Armies	Strategic Objectives
Battle	1-3 Weeks	Field Armies or Army Corps	Operational Mission
Engagement	1-5 Days	Divisions-Companies	Tactical Mission
Action	1-24 Hours	Battalions-Squads	Local Objective
Duel	Minutes	Individuals or Mobile Fighting Machines	Local Objective

The level of combat must be specified for each attrition rate. The difference is due to the proportion of time in which units are committed to combat at each level. The units in an engagement will be committed to combat during almost all of that engagement. During a campaign, however, there are periods when the unit is not in combat and has no battle casualties. The engagement casualty rate for a division therefore, is likely to be much higher than the rate for that same division over an entire campaign consisting of several battles, numerous engagements, and time spent in reserve. The Hierarchy of Combat is the key to understanding these different levels of combat. The definitions of the levels of the Hierarchy of Combat are in Appendix 1.

Sources of Strength and Attrition Data

Strength and attrition data (casualties and materiel losses) are obtained from historical records of combat. There are two kinds of historical records: primary and secondary.

Primary sources are words of witnesses or first recorders of an event. Primary sources are preferred for historical research because the recorder or witness was close to the event in space, time, or both. Primary sources include contemporary accounts and official records.

Secondary sources are derived from one or more primary sources or from other secondary sources. They are susceptible to errors of aggregation, simplification and misinterpretation when they are derived. Secondary sources are used when primary sources are not available or are too costly to use.

Both primary and secondary sources must be approached with skepticism until checked for validity and reliability.

Official Records. Because of the complexities of modern military organization, the staffs of military units are required to produce and maintain a documentary record. These provide the most detailed and contemporaneous record of unit experiences.

In many instances, however, the official records may not be available, or they may be incomplete if available. Sometimes the records have been destroyed due to the vagaries of war. German Army archives of World War I and earlier years were destroyed by Allied air bombardment during World War II. Sometimes the records are destroyed inadvertently by the holders of the records. Some US Army records from World War II have been destroyed to obtain warehouse space for other purposes.

Sometimes the records exist but are not available because of security classification or political problems. The US, for example, does not have access to official Soviet records of World War II. Nevertheless, a great many official records exist and are available to determined historical researchers.

Official records available to the researcher include reports, journals, files, diaries, and operational summaries compiled chronologically by the various staff sections. The usual reporting period is one day, but some reports summarize activities over longer time periods. Reports are produced by the four major staff sections: personnel; intelligence; operations; and logistics.

Personnel reports will usually be the most helpful for compiling strength and personnel casualty data. A typical personnel daily summary will include the information shown in Figure 8.

Figure 8

Data Found in Personnel Reports

- <u>Strength</u> of the organization
    - Authorized
    - Assigned
    - Present for Duty
- <u>Casualties</u>
    - Total
        - Total Battle Casualties
            - Killed in Action (KIA)
            - Wounded in Action (WIA)
            - Captured/Missing in Action (CMIA)
        - Total DNBI
- <u>Replacements</u> and <u>hospital returnees</u>

The reports of logistics sections provide similar data on materiel holdings and losses.

Personnel and logistics reports usually consist of tabulations of numerical data. They do not make too much sense unless correlated with the relevant periodic reports of the operations sections, which provide specific details of the tactical activities of the units. A typical operations report will provide in narrative form the circumstantial context in which the casualties and materiel losses shown in the personnel and logistics reports were incurred. Operational and environmental circumstances covered will include some or all of the information in Figure 9

Figure 9

Data Found in Operations Reports

Location of own front line

Location of own troops

Information on adjacent units and supporting troops

Information on weather conditions and visibility

Brief descriptions of operations in the reporting period

Information on the enemy's dispositions and estimates of his intentions

Information on the combat efficiency of the command

Descriptions of the results of operations

In addition to supplying information about the circumstances of operations, operations reports often provide data on strengths and casualties. This is important, particularly when other records are missing or fragmentary, as is the case with the records of the British Army and Empire/Commonwealth units for World Wars I and II. An example of the use of official records to compile strength and casualty data is presented in Appendix 2.

Data Reliability. Estimating the reliability of historical attrition data is a perplexing problem for the analyst. It is generally conceded that the more recent the data, the more reliable it is likely to be, but each case must be approached individually. It would be a grievous error to assume that any data is reliable until it passes tests of historical criticism. A brief explanation of the method of historical criticism is presented in Appendix 3.

Inaccurate and unreliable data may be encountered in the record of any historical period. The task of the researcher is to separate the wheat from the chaff.

Twentieth Century attrition data is much more reliable than that for earlier eras, but there are still limitations. It is difficult to separate fact from propaganda. Nations tend to avoid giving accurate casualty data. They want to keep bad news from the enemy or their own people; they want to keep good news from the enemy to fool him. Most reports overstate enemy losses and understate friendly losses. In some cases, the official records are difficult to obtain. The US has good records on the US part of the war in Vietnam but no data from the North Vietnamese. Even the US data is suspect. A noted historian of the Vietnam War, Shelby Stanton, makes the following observation.*

> The entire process of accumulating valid (enemy) casualty data was also shrouded (sic) by the shameful gamesmanship practised by certain reporting elements under pressure to "produce results."

Despite these difficulties it is possible to piece together a reasonably accurate record of strengths and casualties in military operations. The key is a thorough understanding of the military operations themselves coupled with an understanding of the way in which strengths and casualties are managed and reported in military organizations. Some important points on

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*Shelby L. Stanton, The Rise and Fall of an American Army: US Ground Forces in Vietnam, 1965-1973 (Novato, Calif.: Presidio Press, 1985), p. xvi.

reliability of strength and casualty data are summarized in Figure 10.

Figure 10

Reliability of Strength and Casualty Data

- o Demonstrably unreliable data has been produced in all historic eras
- o Demonstrably reliable data has been produced in all historic eras
- o Data from earlier eras is less abundant and, generally, less reliable
- o Modern data (20th Century) may be misleading and incomplete but can be tested for reliability by persons familiar with the context and the subject

The successful military analyst will make use of as many adjudged reliable sources as possible, employ comparative analyses, and establish baseline numbers and ranges of variation based upon historical trends, the particular circumstances of the conflict event, and the general historical context within which the event took place.

Understanding Attrition

The remainder of this book deals almost entirely with the loss dimension of attrition. Historical usage of the term "attrition" treats that term as synonymous with losses. In this chapter we have deliberately introduced a broader definition of attrition to mean the balance of losses and returns to duty. The broader concept of attrition is used in resource management, planning and programming, and in personnel management. Moreover, the military analyst is interested primarily in the numerical strength of the military forces, not just the losses. Losses are only one dimension of strength; gains are equally important. Accordingly, we have gone to some length to provide a basic understanding of the fundamentals of strength maintenance.

The following chapters are designed to provide a good understanding of losses in military combat. Most of the attention is paid to personnel casualties. That is where most of the research and analysis effort has been applied. Some basic data and tentative hypotheses on materiel losses are provided to round out the coverage of attrition.

Chapter 2

PERSONNEL ATTRITION: HISTORICAL PATTERNS AND TRENDS

1600, The Benchmark Year

The year 1600 is a very logical starting point for a survey of the historical patterns and trends that form the background of personnel attrition in modern combat. Although gunpowder weapons first appeared on European battlefields in the 14th Century, it was not until the beginning of the 17th Century that guns finally displaced spears, swords, halberds, pikes, and bows and arrows as the principal determinants of battle outcomes.

There is another related, though less important, reason for choosing 1600 as a starting point for the survey. Quantitative data on strengths and losses of military forces in battle is often not very reliable, even for many 20th Century wars. The earlier in history, the less reliable the data. The year 1600 was no crossover point when data miraculously changed from questionable to reliable. However, other cultural and societal trends were combining at that time to complete the transition from medieval to early modern history, with all that implies with respect to historical and scientific rigor.

This will explain why two of the most reliable of the occasional general surveys of battle data begin with the Thirty Years' War, early in the 17th Century: Gaston Bodart's <u>Kriegs-</u>

Lexikon,* and Theodore Ayrault Dodge's "Modern Casualties," an appendix in his four-volume work, Napoleon.**

Having made the case for beginning this survey of historical patterns and trends with the year 1600, it is nevertheless interesting to note that these patterns and trends were logical extrapolations from ancient military history, to the extent that that history is reflected in Dodge's compilation, "Casualties in Some Ancient Battles," in his Caesar.***

Lethality versus Casualties

In military forces exposed to hostile firepower, the percentage of those hit per day of combat has declined steadily, albeit a bit unevenly, over four centuries, despite tremendous increases in the lethality of weapons.

All weapons have at least one common characteristic: lethality. This is the ability to injure and, if possible, to kill people. The history of warfare is a review of the manner in which groups of men have endeavored to impose their wills upon other groups of men by using their weapons more effectively than their opponents or by realizing, or at least approaching, the ultimate lethality potential of their weapons.

Lethality is a comparative thing. Nothing is more lethal than a sword, in the hands of someone who can wield it, to kill a

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*Gaston Bodart, Militaer-historisches Kriegs-Lexikon. (Leipzig and Vienna: C.W. Stern, 1908).

**T.A. Dodge, Napoleon. 4 vols. (Boston: Houghton Mifflin, 1904).

***T.A. Dodge, Caesar. 2 vols. (Boston: Houghton Mifflin, 1892).

single opponent who is within reach of the sword. But the sword's lethality is limited by the factors of time, range, and the physical limitations of the man using it. By assigning values to these and other factors it is feasible to compare the lethality of the sword with the lethality of the hydrogen bomb, or the tank, or any other actual or hypothetical weapon. Weapons that kill more people in shorter periods of time have greater lethality. Figure 11 shows the calculated theoretical lethality index (TLI) values of representative weapons over the course of history.*

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*The theoretical lethality index (TLI) is a measure of the potential number of casualties a weapon can cause per hour based on its own characteristics if employed against an assumed homogeneous, uniformly distributed target array of personnel with a density of one per square meter. TLI is based on the following factors: rate of fire; reliability; accuracy; casualty effect; range; and mobility. For additional information on the TLI see T.N. Dupuy, Numbers, Predictions, and War (Fairfax, Va: HERO Books, 1984).

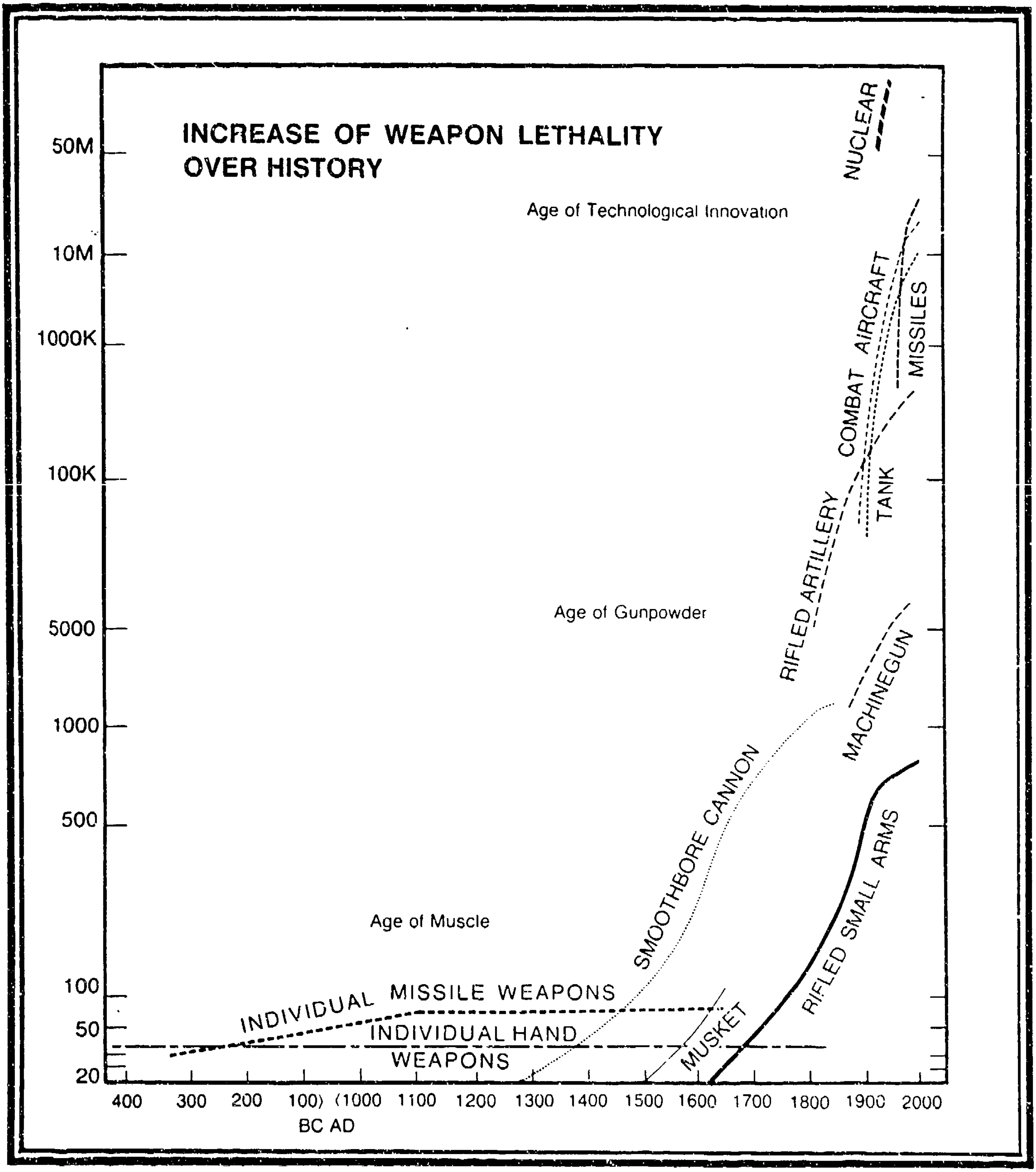
Figure 11

Selected Theoretical Lethality Indices (TLI)

Weapons	TLI Values
Hand-to-Hand	23
Javelin	19
Ordinary Bow	21
Longbow	36
Crossbow	33
Arquebus	10
17th Century Musket	19
18th Century Flintlock	43
Early 19th Century Rifle	36
Mid-19th Century Rifle	102
Late 19th Century Rifle	153
Springfield Model 1903 Rifle	495
WW I Machinegun	3,463
WW II Machinegun	4,973
16th Century 12-pdr Cannon	43
17th Century 12-pdr Cannon	224
Gribeauval 12-pdr Cannon	940
French 75 mm Gun	386,530
155 mm GPF	912,428
105 mm Howitzer	657,215
155 mm "Long Tom"	1,180,681
WW I Tank	34,636
WW II Medium Tank	935,458
WW I Fighter-bomber	31,909
WW II Fighter-bomber	1,245,789
V-2 Ballistic Missile	3,338,370
20 KT Nuclear Airburst	49,086,000
One Megaton Nuclear Airburst	695,385,000

Figure 12 is a semilogarithmic plot of trends in weapon lethality over history. It is not surprising that through the period called the "Age of Muscle," the increase in lethality is quite flat. Since the introduction of gunpowder weapons, however, and particularly since the mid-19th Century, the lethality of weapons has increased steadily and sharply. Because of this great and steady increase in the lethality of weapons over the past 400 years -- particularly as the trend has

Figure 12



INCREASE OF WEAPON LETHALITY OVER HISTORY
Age of Technological Innovation
Age of Gunpowder
Age of Muscle
NUCLEAR
COMBAT AIRCRAFT
MISSILES
TANK
RIFLED ARTILLERY
MACHINEGUN
SMOOTHBORE CANNON
RIFLED SMALL ARMS
MUSKET
INDIVIDUAL MISSILE WEAPONS
INDIVIDUAL HAND WEAPONS
50M
10M
1000K
100K
5000
1000
500
100
50
20
400
300
200
100) (1000
1100
1200
1300
1400
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1600
1700
1800
1900
2000
BC AD

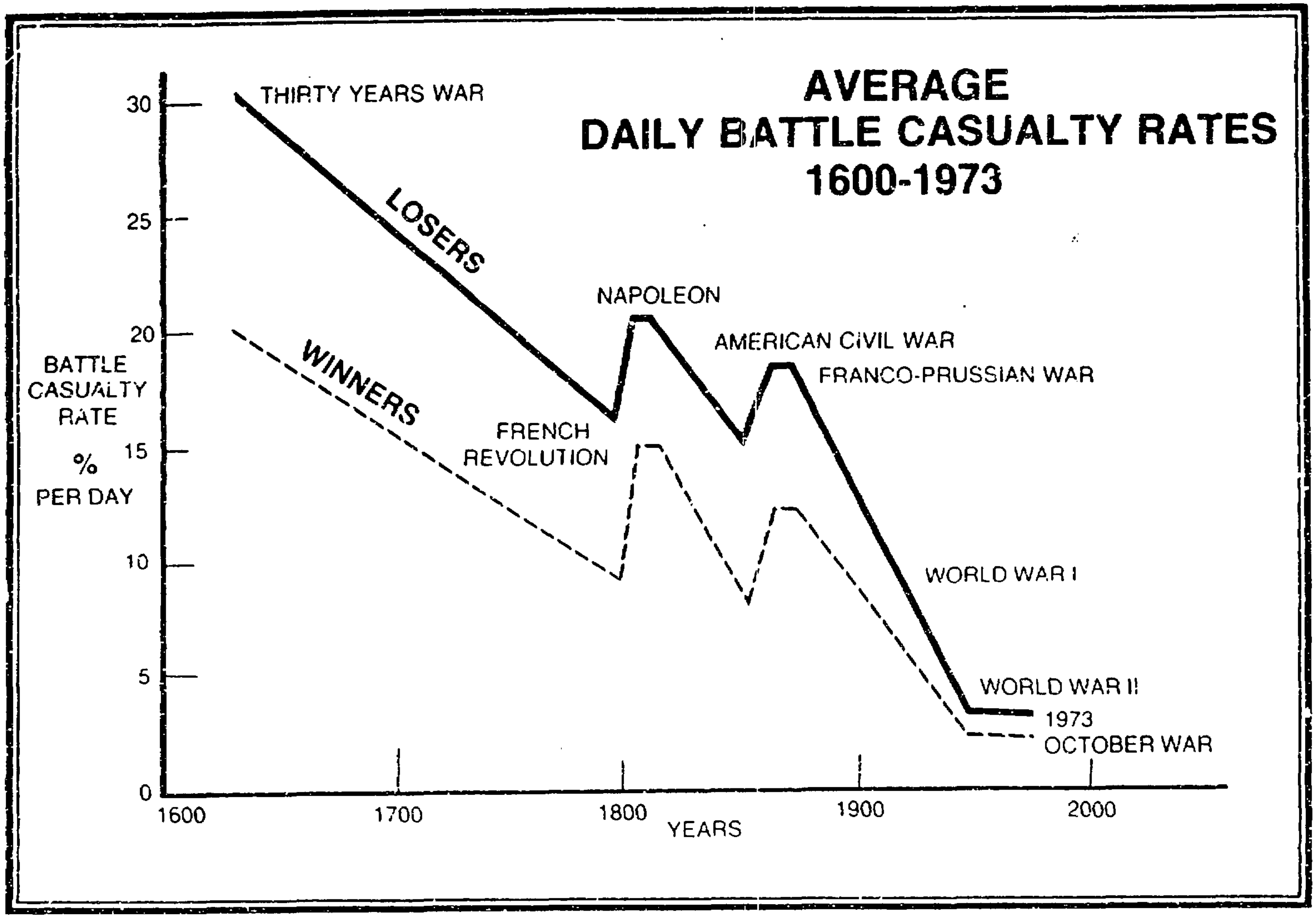
become pronounced in the past century-and-a-half -- it would be logical to assume that the damage inflicted by these weapons in terms of killed and wounded in battle would have increased commensurately. Such an assumption might be superficially logical, but it would be wrong!

Despite the fact that weapons have become more lethal, the battlefield has become rather steadily less deadly over these same four centuries. Figure 13 shows average daily battle casualty rates for winners and losers in combat from 1600 to the present. Casualty rates have gone down because of two significant responses to man's success in producing more weapons and more lethal weapons. First, men have altered their methods of fighting in order to exploit the new weapons. Second, they sought to limit the effects on their own troops of the new weapons in hostile hands. These two combined, and to some extent offsetting, trends have been reflected in the development of new tactics for the employment of troops in battle. Regardless of the weapons, tactics have the purpose of getting troops and their weapons in positions from which they can inflict the greatest harm on the enemy, or to where the enemy can do the least harm to them, or some combination of both of these purposes.

Effect of Dispersion on Casualty Rates

The principal reason for a decrease in casualties despite an increase in weapons lethality has been greater dispersion of combat troops on the battlefield. This greater dispersion has occurred for the most part in response to the increase in lethality of new weapons. As weapons lethality increased, tac-

Figure 13


AVERAGE
DAILY BATTLE CASUALTY RATES
1600-1973
THIRTY YEARS WAR
LOSERS
WINNERS
NAPOLEON
FRENCH
REVOLUTION
AMERICAN CIVIL WAR
FRANCO-PRUSSIAN WAR
WORLD WAR I
WORLD WAR II
1973
OCTOBER WAR
BATTLE
CASUALTY
RATE
%
PER DAY
30
25
20
15
10
5
0
1600
1700
1800
1900
2000
YEARS

tics were adopted which minimized the effectiveness of the enemy's weapons by increased dispersion of the combat forces. The way in which this has occurred is shown in Figure 14, which compares the area occupied over history by a typical army or modern army corps with a strength of about 100,000 men.

Figure 14

Historical Army Dispersion Patterns
(Army or Corps of 100,000 Troops)

	Antiquity	Napoleonic Wars	American Civil War	World War I	World War II	1973 Arab-Israeli October War
Area occupied by deployed force, 100,000 strong (Sq Km)	1.00	20.12	25.75	248	2,750	3,500
Front (Km)	6.67	8.05	8.58	14.33	48	54
Depth (Km)	0.15	2.50	3.00	17.33	57	65
Men per Sq Km	100,000	4,970	3,883	404	36	29
Square meters per man	10.00	200	257.5	2,475	27,500	35,000

In antiquity an army of 100,000 men occupied an area of about 1.0 square kilometer, with each soldier's share being about 10 square meters on the average. It was not often that armies as large as 100,000 men were assembled in antiquity, but it did occur. For instance, the army of Xerxes that crossed the Hellespont in the year 480 BC was certainly larger than 100,000 men, as was the army that Darius III brought to the field of Arbela against Alexander. Roman armies on several occasions faced more than 100,000 men in their wars against Mithridates and such barbarian hosts as those of the Teutones and Cimbri.

By the time of the Napoleonic Wars an army of 100,000 men occupied an area of about 20 square kilometers, with the average space per soldier being 200 square meters. The troops were not distributed uniformly at this density, being grouped in more compact unit formations with relatively large spaces between units, both laterally and in depth.

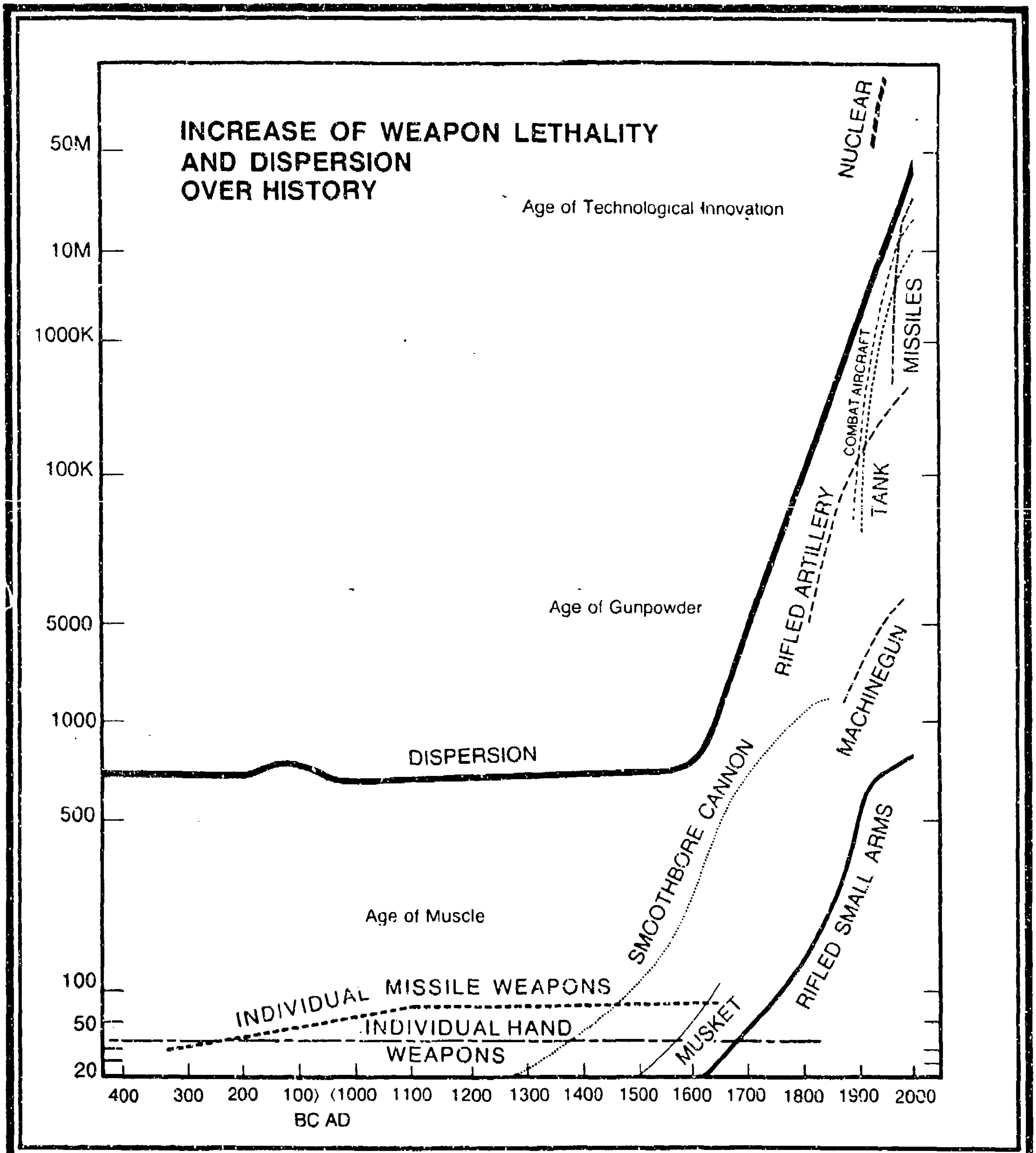
In the 20th Century the average space occupied by each soldier increased steadily as weapon lethality increased. The dispersion increased dramatically in World War I and even more so in World War II.

By the time of the 1973 Arab-Israeli War the area occupied by an army of 100,000 men (that of the Egyptians, for instance) was about 3,500 square kilometers, with an average density of 29 men per square kilometer, or 35,000 square meters per man.

The increase in troop dispersion is represented graphically in Figure 15 by a dispersion line superimposed over the lethality curves of Figure 12.

The interaction of increased dispersion with increased weapons lethality is demonstrated in Figure 16. In this figure the lethality of all of the weapons in a typical army of 100,000 men has been estimated for several important historical periods. The relationship between dispersion and lethality varies, but both lethality and dispersion have increased over two centuries. Compared to antiquity, the lethality of a modern army of 100,000 has increased 2,000-fold, while dispersion has increased 5,000-fold. Thus, the average lethality density of a modern army is less than half that of an army of antiquity. It is notable that

Figure 15


INCREASE OF WEAPON LETHALITY
AND DISPERSION
OVER HISTORY
Age of Technological Innovation
Age of Gunpowder
Age of Muscle
NUCLEAR
MISSILES
COMBAT AIRCRAFT
TANK
RIFLED ARTILLERY
MACHINEGUN
DISPERSION
SMOOTHBORE CANNON
RIFLED SMALL ARMS
MUSKET
INDIVIDUAL MISSILE WEAPONS
INDIVIDUAL HAND WEAPONS
50M
10M
1000K
100K
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the average lethality densities of World War II were half as great as for World War I, due primarily to the availability of motor vehicles to move reserves in World War II. This permitted greater dispersion without fear of breakthrough since there had not been a significant increase in weapons lethality. This in turn resulted in substantially lower casualty rates in World War II than in World War I.

Based on current doctrine, the projected average lethality density for a war in Europe in the near future could be twice as much as was experienced during World War II. Once conflict starts, however, doctrinal dispersion tends to adjust to the realities of weapons lethalities.

Figure 16

Trends in Lethality of Ground Armies

Typical army of 100,000 in the following wars	Area sq km	Lethality TLI in millions	Lethality Compared to antiquity	Average Lethality per sq meter
Antiquity	1	2	1	2.00
Napoleon Era	20	5.5	2.8	0.27
American Civil War	26	14.3	7.2	0.55
World War I	250	233	117	0.94
World War II	2,750	1,281	641	0.47
1973 October War	3,500	1,650	825	0.47
Europe, 1985-90	5,000	4,098	2,049	0.82

There were two periods shown in Figure 13 in which the generally downward trend of the casualty rates since 1600 was reversed temporarily. The first is a period of about ten years during the Napoleonic Wars; the second is a period of similar length encompassing the American Civil War, the Austro-Prussian War, and the Franco-Prussian War. It is useful to examine these two counter-trend periods in more detail, since they suggest the possibility that there could be similar changes of direction in the casualty rate trend in the future.

Figure 17

Daily Battle Casualty Rates
17th to 19th Centuries

	Winner	Loser
c. 1630 (Gustavus)	15%	30%
c. 1795 (French Revolution)	9%	16%
c. 1812 (Napoleon)	15%	20%
c. 1848 (Mexican War)	8%	15%

Figure 17 shows the daily battle casualty rates for key periods from the 17th to 19th Centuries. The decline in casualty rates for both winners and losers from the Thirty Years' War through the French Revolutionary Wars to the Mexican-American War is interrupted by the higher casualty rates of Napoleon's imperial battles, beginning with Eylau early in 1807. There appear to be two principal reasons for this. One reason is that Napoleon's enemies had begun to learn his method of warfare, which led to an increase in the efficiency of the battlefield performance on both sides, with an inevitable rise in casualty rates on both sides. This caused the Emperor to demand greater efforts from his commanders and troops, again causing a rise in casualty rates on both sides, and particularly his. The other reason is that these higher casualty rates caused a general overall decline in the quality of the forces Napoleon led to battle. This forced him to rely more on the effect of mass attacks and less on skilful maneuver, again with an inevitable rise in casualty rates.

Effect of the Conoidal Bullet on Casualty Rates

The perturbation in the downward casualty trend shown in Figure 13 for the period between 1861 and 1871 was due to a very different kind of phenomenon.

The reason for the increase in casualty rates in the American Civil War was the introduction of the conoidal bullet -- the so-called Minie "ball" -- and its substitution for the old spherical ball in rifled muskets. This caused a remarkable improvement in the range, accuracy, and power of the infantryman's weapon. Effective ranges were increased from less than 200 meters to over 1,000 meters. Even at that extended range, the conoidal bullet could penetrate four inches of solid pine.

Figure 18

Causes of Battlefield Casualties in the 19th Century

	Before 1850	After 1860
Artillery	40-50%	8-10%
Infantry Small Arms	30-40%	85-90%
Saber and Bayonet	15-20%	4-6%

Prior to 1850, as shown in Figure 18, artillery had caused about one-half of the battle casualties; infantry small arms caused about one-third; and the saber and bayonet accounted for the rest. A short time later, during the three major wars between 1861 and 1871, these proportions had changed dramatically. The saber and bayonet became only incidental causes of casualties. The major change was the reversal of relative lethality between infantry weapons and artillery, with the rifle-musket firing the conoidal bullet accounting for 85-90% of the casualties and artillery only for 10%.

For all practical purposes the infantryman's rifle had achieved the same effective range as the artilleryman's cannon -- as far as the next ridge line. Riflemen could fire effectively at hostile artillery cannoneers on that ridge, and the cannoneers were much more exposed to such fire than were the generally-prone riflemen nearby. Artillery effectiveness declined as infantry lethality soared, and all casualty rates doubled. Infantry bayonet charges and cavalry saber charges became suicidal against hostile riflemen, and so were rarely used.

In terms of immediate effects upon tactics, doctrine, and casualty rates, the introduction of the conoidal bullet to the battlefield was the most significant change in weapon lethality in all of military history. Not even the machine gun, the tank, or the fighter-bomber has had such a dramatic impact on casualty rates.

Later on, however, artillery gradually regained its predominance as the principal cause of casualties on the battlefield. Improvements in recoil mechanisms, in the accuracy of rifled cannon, and even in the destructiveness of high-explosive projectiles played important but secondary roles in this evolutionary process.

The principal reason for the return of artillery as the cause of more than 50% of the casualties in World Wars I and II was the simple field telephone, an implement with no inherent lethality. The field telephone permitted the artillery to leave exposed positions on ridges, and take position behind the cover and concealment of terrain and manmade masks, and to place fire on targets by indirect fire techniques. Only the observer needed to expose himself to observe the target and adjust the fire of the concealed and protected artillery weapons upon it.

Effect of Posture and Success on Casualty Rates

A recent analysis by HERO of 595 battles or engagements from 1600 to 1973 indicates that posture (attacker or defender) and success (win or loss) have had an effect historically on casualties incurred. Figure 19 presents some data on those battles with respect to the success, strength, and attrition rates of the attacker.

In Figure 19 the 595 battles have been grouped chronologically into seven sets of battles. The 19th Century battles have been split into two groups at 1859 because of the introduction then of the conoidal bullet. The first 20th Century group from 1900 to 1939 includes 122 battles of World War I and 20 other battles of that time period. Three statistics are presented for each group: the percentage of battles in which the attacker won; the percentage of battles in which the attacker had

Figure 19

Selected Data on 595 Battles

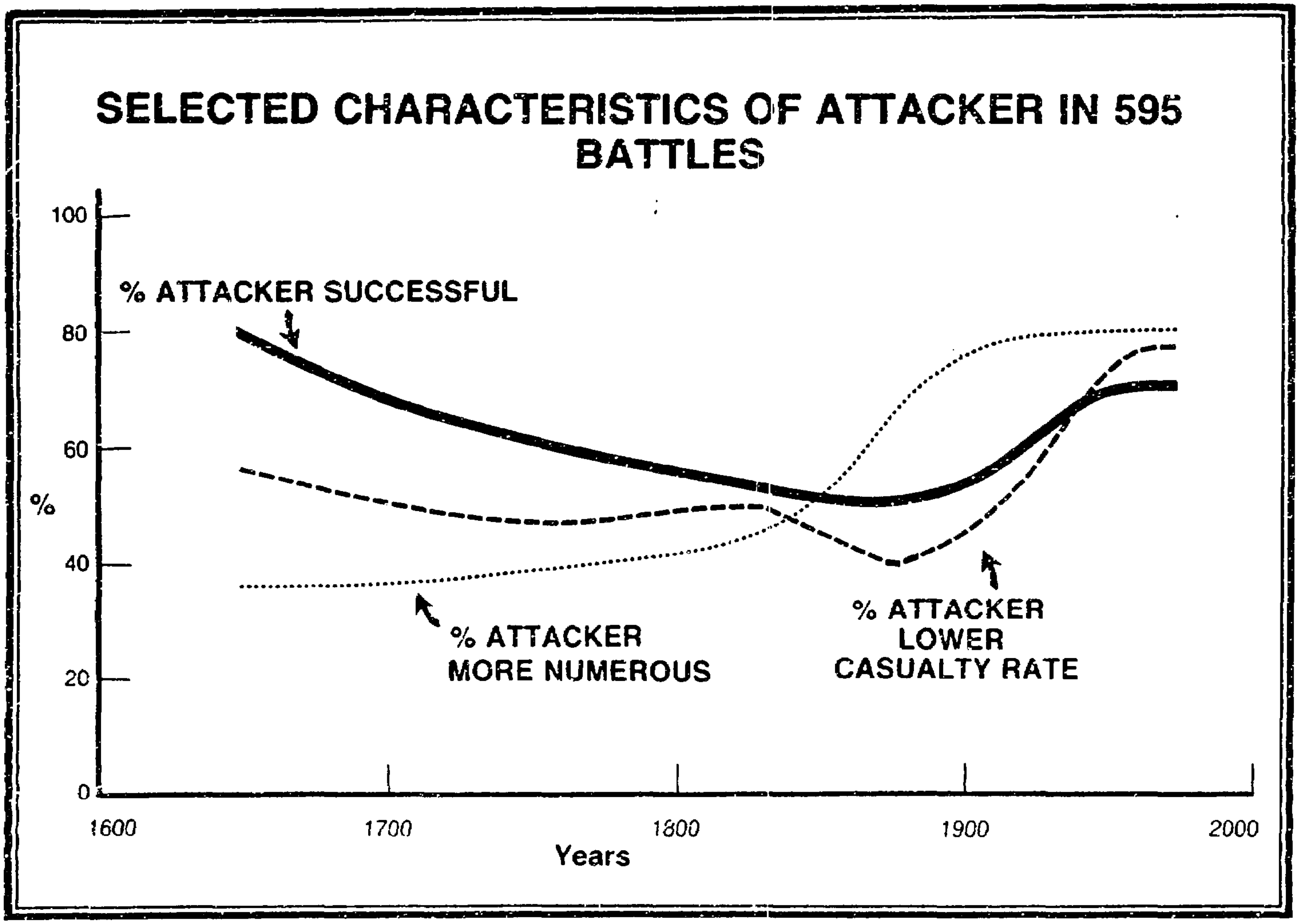
Time Period	Number of Battles	Per Cent Attacker Successful	Per Cent Attacker Numerically Stronger	Per Cent Attacker Lower Casualty Rate
1600-1699	47	77	36	55
1700-1799	65	59	40	46
1800-1859	55	56	44	51
1860-1899	71	49	66	39
1900-1939	142	59	75	58
1940-1945	162	66	90	69
1967-1973	53	66	45	72
Total:	595			

the percentage of battles in which the attacker had a larger force than the defender; and the percentage of battles in which the attacker had lower casualty rates than the defender. To aid in understanding the phenomena the data has been plotted in Figure 20.

The data in Figures 19 and 20 demonstrate the importance of the human factor in War and its interaction with weapons technology.

From 1600 until the present the attacker has been successful in three out of five battles. In the 17th century the attacker was successful more than three-fourths of the time, while in the latter portion of the 19th century the attacker was successful just slightly less than half of the time. During the first two and a half centuries after 1600, success usually crowned the efforts of the side that seized the initiative and attacked, regardless of size. The decline in the percentage of attacker success from 1600 through 1859 suggests that as gunpowder weapons became more lethal, firepower was able more and more to offset

Figure 20



SELECTED CHARACTERISTICS OF ATTACKER IN 595 BATTLES
% ATTACKER SUCCESSFUL
% ATTACKER MORE NUMEROUS
% ATTACKER LOWER CASUALTY RATE
%
100
80
60
40
20
0
1600
1700
1800
1900
2000
Years

initiative and elan.

The effect of the human factor in war and its relationship to weapons technology explains what is perhaps the greatest apparent incongruity in the historical record of warfare. Why was it that in the 17th century the attacker was successful more than three-quarters of the time, yet was numerically superior only about one-third of the time? (In other words, a numerically inferior attacker won more than half the time.) There seem to be two reasons for this, both of which are human factors. First, the attacking force was the one that had the greatest confidence in victory either because of an awareness of larger numbers or of better quality troops. This alone would suggest that the attacker would likely be successful more than half of the time. Second, in the 17th century it was obvious that the relatively crude weapons of the defender could not slow or stop the attacker before he was able to bring his superior numbers or superior troops to bear at close quarters. Against the weapons of the day, initiative seems to have augmented an initial numerical or effectiveness superiority, while defensive posture without effective firearms provided the defender with little or no advantage.

Presumably it has been confidence in overall combat power superiority that has influenced attackers throughout the historical period from 1600 to the present. Only during the relatively brief period from 1860 to 1899 has the attacker not been victorious more than half of the time. This suggests that more often than not, the commander of a force risks an attack when his estimate of the situation suggests that success is likely. Attacker success about three times out of five thus appears to be quite reasonable.

The sudden drop in percentage of attacker success about 1860 coincides with the introduction to the battlefield of the conoidal bullet for the rifled musket. As demonstrated at Antietam, Gettysburg, and Cold Harbor, defenders armed with rifled muskets had an advantage that an attacker could overcome less than half of the time.

However, the relative success of the defender did not last long as commanders began to realize that it was suicidal to attack well-prepared infantry in defensive positions. About 1865 Moltke remarked that the effect of the new infantry weapons was such that success in war depended upon defensive tactics combined with offensive strategy. He won at Metz and later at Sedan, the decisive battle of the Franco-Prussian War, by maneuvering to place his army on the line of communications of his enemies; then the defensive firepower of his infantry weapons defeated the French attacks attempting to break out of the trap.

This state of affairs continued certainly up to and through World War I even though that is not obvious from the data,which is somewhat skewed. Most of the World War I battles and engagements in the data base are for engagements between Americans and Germans toward the end of the war when, as American intelligence reports pointed out, their German opponents were "tired and depleted." This gave the Americans, with a great numerical superiority, a consistent advantage that is reflected in the statistics for successful attack.

By World War II the balance favoring the attacker was again comparable to which it had been before the Industrial Revolution. The slight decline in the proportion of attacker successes from World War II to the Arab-Israeli Wars (from 79 to 73 percent) is explicable by the fact that while the Israeli attackers were successful at least 79% of the time, the Arab attacks (of which there were many fewer) were successful less than half of the time.

Numerical superiority was considered necessary by the attacker in 90% of the battles of World War II in the data base. In most of these the Germans were defenders. If a higher proportion of German attacks had been included, the figure would be less than 90%. Almost all of the instances of a numerically inferior force daring to attack a numerically superior defender in World War II were due to German confidence in their relative combat effectiveness superiority over their enemies. With one or two exceptions, these were German attacks on the Eastern Front.

The 45% figure shown in Figure 19 for the percentage of attacker numerical superiority in the Arab-Israeli Wars might be interpreted as an abrupt change in the trend just discussed. In fact it is not. The many instances of attacks by numerically inferior forces against larger defending forces are all cases in which the Israelis, confident of their relative combat effectiveness superiority of about two-to-one, and often with the added advantage of surprise, were willing to risk an attack against numerically larger forces. Thus the desired line in Figure 20 for "attacker more numerous" is an approximation of the trend for the numerical relationship of the attacker to defender in the late 20th Century for forces approximately even in relative combat effectiveness.

There are two relevant lessons from this analysis: (1) the attacker tends both to be more numerous than the defender, and to win more often than the defender; and (2) because winners have lower casualty rates than losers, this means also that attackers tend to have lower casualty rates than defenders.

The Concept of Relative Combat Effectiveness

At this point it is useful to discuss the phenomenon of relative combat effectivenss. Detailed analyses of the battle statistics of World War I, World War II, and the Arab-Israeli Wars have led to an understanding and quantification of this phenomenon.*

In World Wars I and II the Germans had a relative Combat Effectiveness Value (CEV) of about 1.2 in comparison with the Western Allies -- British, French, and Americans. In other words, 100 German soldiers in combat units were the equivalent of about 120 soldiers of the Western Allies in comparably-equipped units. This was not because the German soldiers were braver, stronger, more intelligent, more highly motivated, or even necessarily more warlike. It was because the Germans had

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*See T.N. Dupuy, Numbers, Predictions, and War (rev. ed., Fairfax, Va.: HERO Books, 1985), passim, and Chapter 7 particularly. See also, T.N. Dupuy, A Genius for War: The German Army and General Staff, 1807-1945 (Fairfax, Va.: HERO Books, 1984), Appendices C and E. See also T.N. Dupuy, Elusive Victory: The Arab-Israeli Wars, 1947-1974 (Fairfax, Va.: HERO Books, 1984), Appendices A and B.

organized and prepared themselves for war more efficiently and more professionally than had their opponents and thus were more effective in combat units. This superiority was demonstrated consistently in both world wars, when the Germans attacked, when they defended, when they had air superiority, when they did not, when they were successful, and when they were defeated. The Germans lost the wars, of course, because their enemies were able to assemble against them forces that outnumbered them by much more than their 1.2 combat effectiveness superiority.*

On the Eastern Fronts of the two world wars the German relative combat effectiveness superiority over the Russians was even greater, generally ranging between factors of 2.0 and 3.0. In other words, 100 Germans in combat units were the equivalent of more than 200 Russians. In World War I the Russians were unable to mobilize enough manpower to overcome the German relative combat effectiveness superiority. In World War II, however, the Soviets outnumbered the Germans by more than 3.0 to 1.0, and they won the war.

This same relative combat effectiveness phenomenon has been a major factor in the outcomes of all of the Arab-Israeli Wars. While the effectiveness of their opponents has varied (Jordanians most effective, Iraqis least effective), the Israeli combat effectiveness superiority over their Arab opponents has averaged about 2.0. In other words, 100 Israelis in combat have been at least the equivalent of 200 Arab soldiers in comparably equipped combat units. Again it must be stressed that this is not a

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** Dupuy, Genius, passim, particularly Chapters 11 and 15.

measure of the worth or capability of individual soldiers, but rather a reflection of the Israeli ability to organize and prepare themselves for war more efficiently and professionally than their Arab opponents. The Arabs have never been able to accumulate enough numerical superiority on the battlefield to offset this Israeli CEV advantage.

Relative Combat Effectiveness has a definite impact on casualty rates. The force with superior relative combat effectiveness generally has lower casualty rates than the inferior force. This phenomenon will be discussed more in the next chapter.

Major Historical Patterns & Trends

The major historical patterns and trends with respect to attrition in ground warfare are consistent from 1600 up to the present day. They are as follows:

--Increases in weapons lethality have been offset by increased dispersion of troops so that daily battle casualty rates have declined from 1600 until the current era.

--Winners consistently have lower casualty rates than losers. Since attackers tend to win more than defenders, this means that attackers have lower casualty rates than defenders most of the time.

--The force with the higher relative combat effectiveness tends to have lower casualty rates than the opposing force. This is because forces with higher combat effectiveness use their weapons more effectively, are less likely to incur damage due to tactical or doctrinal errors and (although this is perhaps a cause more than an effect) tend to win, other things being equal.

These major patterns and trends provide a basis for examination of more detailed personnel attrition factors and relationships in Chapter 3.

Chapter 3

PERSONNEL ATTRITION: TWENTIETH CENTURY RATES

This chapter addresses casualty rates in modern warfare in the 20th Century. This experience is recent enough to have direct validity for military analysts dealing with current combat. The major topics covered in this chapter are the effect of sustained combat on casualties, the impact of relative combat effectiveness on casualty rates, and the relationship of unit size to casualty rates.

Impact of Sustained Combat on Casualties

In Chapter 2 it was shown that daily battle casualty rates have declined fairly steadily over the past four centuries. This was true despite brief, temporary, upward surges in rates at the beginning of the 19th Century and in the middle of that century.

However, simply because casualty rates have been declining fairly steadily over the past 400 years does not mean that war has become either less dangerous or less horrible. The daily battle casualty rate is a measure of the percentage of a force that incurs casualties during exposure to hostile fire for 24 hours. Prior to the 20th Century battles usually lasted only for one day or less, and there were periods of days, weeks, and months between battles. In the 20th Century, particularly during World War I, troops have been exposed to hostile fire in battles that continued day after day. The fact that daily battle casualty rates have been lower during the past century has been offset by the fact that these lower daily losses have been sustained day after day on a continuous basis.

The effect of sustained daily losses upon total attrition can be seen in Figure 21.

Figure 21

Casualty Rates of US Armies, 1846-1971*

War	Average Annual Casualty Rate Percent	Average Daily Casualty Rate Percent	Average Daily Division Engagement Casualty Rate Percent
Mexican War (1846-48)	9.90	0.03	8.0
Civil War (1861-65)	24.26	0.07	13.0
Spanish-American War (1898)	5.62	0.02	**
Philippine Insurrection (1899-1903)	2.64	0.01	**
World War I (1918)	52.86	0.14	4.0
World War II (1942-45)	17.79	0.05	1.2
Korean War (1950-53)	14.72	0.04	0.9
Vietnam War (1966-71)	14.17	0.04	**

*Rates for ground combat troops in the combat theaters.

**No comparable division casualty rates are available or applicable

Figure 21 shows clearly the importance of specifying the exact casualty rate being stated. The daily engagement rates, which tend to measure the casualties during actual combat, are much higher than the daily rates for the Army as a whole.

The most deadly war in US history was World War I when, for a six-month period in 1918, US Army casualties were 26.4% of combat strength in France. This is the equivalent of an annual casualty rate of 52.9% of the average strength of forces in the combat theater. Although the average daily battlefield casualty rate was less than half of the average daily casualty rate in the Civil War, the accumulated casualty rate per year was more than twice as great. This apparent paradox is due to the fact that there were lulls of days and weeks between relatively brief battles in the Civil War, whereas in World Wars I and II battles often continued day after day for weeks or months.

Figure 22

Casualty Rates in World Wars I and II*

	Average Annual Casualty Rate Percent	Average Daily Casualty Rate Percent	Estimated Daily Engagement Casualty Rate Percent
World War I			
United States	52.9	0.14	4.0
British Empire	42.8	0.12	4.0
France	46.9	0.13	4.0
Russia	63.3	0.17	6.0
Germany	47.2	0.13	3.0
Italy	46.6	0.13	**
World War II			
United States	17.8	0.05	1.1
United Kingdom	17.5	0.05	1.2
France	16.3	0.04	1.2
USSR	88.2	0.24	3.5
Germany	44.9	0.12	2.0
Italy	19.8	0.05	**
Japan	25.1	0.07	**
China	12.2	0.03	**

*Rates for ground combat troops in the combat theaters.

**Not estimated.

Equally interesting is the comparison of annual casualty rates for the principal armies in World Wars I and II in Figure

22. In World War I only the Russians had a greater overall casualty rate than did US forces. However, the annual casualty rates for French, Germans, and British for the first year of the war (1914-1915) were much higher by a factor of at least 1.5 than they were for the war as a whole, and they were undoubtedly higher for that year than the US casualty rate for 1918.

In World War II the annual casualty rate for the Germans was approximately the same as for World War I. The annual and daily rates for the Russians were even higher than they had been for World War I. The annual casualty rates for all of the other major participants were considerably lower.

The daily casualty rates in the two major Middle East wars of 1967 and 1973 are shown in Figure 23. The Middle East wars were so brief, lasting only a few days or weeks as opposed to several years, that no real comparison of annual rates is possible. The average daily casualty rates for the participants in these recent wars were much higher than those of World War II. There are two reasons for this. First, casualty rates are usually higher at the outset of a war than later on when both sides become both exhausted and more careful. Second, the participants in the Middle East wars knew that the wars would be brief, since a cease fire would be imposed by the superpowers and/or the United Nations, and they did not have to husband strength for a long war. The daily engagement casualty rates for both sides in the Middle East wars, however, were very similar to those for World War II.

Figure 23

Casualty Rates for Arab-Israeli Wars

	Duration (Days)	Average Daily Casualty Rate Percent	Average Daily Engagement Casualty Rate Percent
1967 War			
Israel	6	0.37	2.5
Egypt	3	2.07	3.0
Jordan	3	1.90	3.5
Syria	2	1.50	3.0
1973 War			
Israel	19	0.21	1.5
Egypt	19	0.42	1.9
Syria	17	0.41	2.5

Relative Combat Effectiveness and Casualty Rates

In order to use casualty rates to gain some insights about relative combat effectiveness, it is useful to refer to the data in Figure 24.

Figure 24

Casualty Data for Selected Groups of Battles

	Average Personnel Strength	Average Daily Number of Casualties	Average Daily Engagement Casualty Rate Percent
American Civil War (8 Battles)			
Union	68,250	7,849	11.5
Confederacy	50,193	7,529	15.0
World War I (9 Battles in 1915)			
British	13,628	1,138	8.5
German	18,133	1,034	5.7
1973 Arab-Israeli War (33 engagements)			
Israelis	14,593	263	1.8
Arabs	51,296	1,385	2.7

First, let's look at the Civil War figures shown. The Union forces in those eight battles, had a force preponderance of about 36%. The Confederates suffered casualties at a rate 30% greater than did the Union, but the average numbers of casualties of the Union and Confederate troops in each of these battles was about the same. The strengths were different, and the rates were different, but the actual numerical losses for the opposing sides showed a difference of only about 4%, with the very slightly greater loss suffered by the larger side.

The same comparison between the British and German divisions engaged in nine battles in 1915 shows a difference. The German numerical strength preponderance was about 33%. The average German loss in these battles was 1,034 casualties per day; the British loss was 1,138, a 12% difference. This time the greater loss was suffered by the smaller force.

Finally, the same comparison can be made between the Israelis and the Egyptians and Syrians in the 1973 War. The strength preponderance in favor of the Arabs was 350%, but on the average they suffered losses nearly 2.5 times as great as did the Israelis.

Many considerations influenced these casualty rates and figures, but at the moment it is useful to examine just one of those considerations -- the relative combat effectiveness of the opposing forces.

Analyses of the American Civil War reveal that while there were often substantial differences in the leadership qualities of the opposing commanders, the fighting values of Union and Confederate troops were close to identical.

As noted in the previous chapter, similar analyses of World War I and World War II data reveal that the Germans consistently had about a 20% relative combat effectiveness superiority over the Western Allies. In the Arab-Israeli wars of 1967 and 1973 the Israeli combat effectiveness value was close to 2.0 with respect to the Egyptians, and about 2.5 with respect to the Syrians.

The data in Figure 22 suggest a relationship between daily engagement casualty rates in combat and relative combat effectiveness. Troops with the higher combat effectiveness appear to inflict more casualties than they suffer, and to about the same degree. The Union and Confederate troops were about equal in relative combat effectiveness, and they each had about the same casualties. The Germans were more combat effective than the British and inflicted more casualties on them. The Israelis had a considerable advantage in combat effectiveness over the Arabs and also inflicted many more casualties on them. This relationship is confirmed by a more general analysis of hundreds of sets of battle data from World War I, World War II, and the Arab-Israeli Wars. Although casualties are only one of several results used to define combat effectiveness, the ability to inflict casualties on the other side appears to be almost directly proportional to the relative combat effectiveness ratio of the two sides.*

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*See Appendix 4 for an explanation of the way in which relative combat effectiveness is calculated. See also the conceptual discussion of relative combat effectiveness in Chapter 2.

Relationship of Casualty Rates to Force Size

Small force casualty rates are higher than those of larger forces under the same circumstances. The first person to notice this phenomenon, apparently, was Theodore Ayrault Dodge, an American historian who in the late 19th and early 20th centuries, wrote a monumental nine-volume series of books on the "Great Captains" and on military history in general from antiquity to the Battle of Waterloo. Although Dodge evidently did not realize it, this phenomenon of higher casualties for smaller forces was and is essentially a manifestation of the concept of "friction in war," about which Clausewitz had written half a century earlier.

There are two principal reasons for this phenomenon. The first is that small combat forces, at least through company size, have very few individuals not directly related to combat. Beginning with battalions, regiments, and brigades, however, there are increasing numbers and proportions of staff and support personnel and units who are involved only rarely in combat activities.

The second reason for the phenomenon is Clausewitzean friction. The larger a force, the greater the number of human interactions among individuals and groups, imparting an inherent inefficiency to combat activities which can be kept to a minimum, but not eliminated, by efficiency in organization, training, communications, and control procedures. Thus, as forces become larger, there are increasing delays in the performance of missions and compliance with orders on both sides of interactions between opposing forces. Troops are exposed to hostile fire less promptly, and there is comparable diminution in the promptness and efficiency with which response is made to that hostile fire. To some extent, there is an unintended cooperation in the lowered efficiency, and lowered attrition rates, for both sides when large forces are engaged.

On the basis of data from 200 engagements or battles in World War II (involving 400 sets of attrition data), the relationship shown in Figure 25 for casualty rates of forces of different size has been derived.

Figure 25

Relationship of Unit Size to Casualty Rates
(US Experience in World War II)

Unit	Approximate Strength	Average Daily Engagement Casualty Rates Percent
Company	200	21.0 (est)
Battalion	800	9.5
Brigade (Regt.)	3,000	2.6
Division	15,000	1.0
Corps (3 Divs.)	65,000	0.6
Corps (4 Divs.)	90,000	0.4
Army (3 Corps.)	250,000	0.3

There is an apparent anomaly created by this strength-size attrition phenomenon. The daily casualty rates of a corps will always be less than the rates of the engaged divisions of the corps for the same day; the casualty rate of a division will be less than the rates of its component brigades that are engaged on that same day, and so on down the line. This is only due to a small extent to the presence of larger staffs and support units in the larger formations. It is primarily due to the fact that small units will be engaged more intensively, but for briefer periods, than will the larger formations to which they belong.

Range of Twentieth Century Casualty Rates

It is difficult to draw definite conclusions on the meaning of 20th Century casualty rates based on the data now available. The casualty rates which are significant for military analysis and planning are the battlefield or engagement rates which indicate casualties which are incurred during periods of actual combat. However, the number of engagements for which these rates have been calculated is quite small compared to the number of engagements which occurred. It is estimated that there were 4,000 to 5,000 division-level engagements during World War II. HERO has collected detailed casualty data on only 200 of these. The sample of 200 is neither representative nor random, and the utility of statistical analysis of the sample is limited. The amount of engagement casualty data which has been collected and analyzed at the regimental or battalion level is even smaller. Thus, it is not possible at this time to provide definitive conclusions on the battlefield casualty rates for World War II.

Korean War and Vietnam War casualty data is available for US forces, but there has been no systematic assessment of battlefield casualty rates for these wars except for the figures cited in this chapter.

The Arab-Israeli Wars of 1967 and 1973 have been examined more comprehensively than World War II, and the data for these wars is quite complete. Unfortunately, there is no way to transfer this experience directly to the forces of the United

States, NATO, and the Soviet Union.

Nevertheless, it is possible to establish the approximate range of values for casualty rates which have been experienced by major combatants during wars of the 20th Century. These ranges provide the best available basis for predicting casualty rates for future combat of the same kind.

The following general statements may be made for conventional combat in a major (non-nuclear) war or a regional war in which the fighting is more or less continuous from start to finish:

--For the United States, Germany, the United Kingdom, France, and Israel the average daily battlefield casualty rate for a division ranged from 1.1% to 1.5%, and the average daily casualty rate for the entire force ranged from 0.05% to 0.27%. The high end of the range is represented by Germany in World War II and Israel in 1973.

--German casualty rates were higher than Allied rates during World War II because the Germans were fighting a losing defensive war for the last two years. There is reason to believe that German Army casualty rates in future combat would be comparable to those posited for other NATO armies.

--For the Soviet Union the daily battlefield casualty rate for a division ranged from 3.5% to 6.6% and the average daily casualty rate for the entire force ranged from 0.12% to 0.24%. There is no reason to believe, however, that these very high rates (compared to those of other combatants) will apply to Soviet forces during future combat.

--For Arab armies, the daily engagement casualty rate ranged from 1.9% to 3.5%, and the average daily casualty rate for the entire force ranged from 0.21% to 2.07%. There is reason to believe that casualty rates at the low end of these ranges will be appropriate for future combat.

Chapter 4

PERSONNEL ATTRITION: TWENTIETH CENTURY RELATIONSHIPS

In this chapter some of the important characteristics of personnel casualties in modern warfare are examined. These include the relationship of killed to wounded, impact of medical care on attrition, disease and non-battle casualties, causes of casualties, and the distribution of casualties by grade and branch.

Relationship of Killed to Wounded in Battle

One of the most consistent relationships in battle statistics has been that between killed and wounded in battle. In his books on ancient warfare, Dodge noted that the standard relationship in ancient battles was between 2.2 and 2.1 men wounded for every man killed -- for the winners. For the losers he simply states: "usual massacre."* In the casualty statistics for Napoleon's wars the relationship is similar to that in antiquity, but Dodge notes that the relationship of wounded to killed in the German armies in the Franco-Prussian War was 2.6 to 1.0.**

Dodge undoubtedly did not distinguish between "killed in action" (KIA) and "died of wounds" (DOW) as is done in compilations of modern casualty statistics in most countries.

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*Theodore A. Dodge, Alexander (Boston: Houghton Mifflin, 1890); Hannibal (Boston: Houghton Mifflin, 1891), Caesar (Boston: Houghton Mifflin, 1891).

**Dodge, Napoleon.

Nor would this have made any difference in antiquity; men who were hit generally either survived the battle or they did not. About one in three on the winning side did not; two in three did. However, it is evident from other sources that Dodge might have been more discriminating. In a reference cited by Beebe & DeBakey* (Gunshot Injuries, by T. Longmore, London, 1877) the average relationship between wounded and killed in a number of wars between 1704 and 1871 is given as about 4.0. We find from official US Army records for the Mexican and Civil Wars that the relationship of wounded to killed was 3.72 and 4.55 respectively in those wars, while the relationship of surviving wounded to KIA and DOW was 2.18 and 2.38 respectively.

The figures in this section are based on the data in Table C, "US Army Casualties in Wars of the 19th and 20th Centuries," which is a definitive compilation of the battle and non-battle casualties of US Army in all wars in which the United States has been engaged since the first compilation of detailed medical statistics in 1819. For wars before World War II, Table C is based almost entirely upon data in Beebe and DeBakey and Love.** In the light of the reliability of these authors, their careful research in the medical archives, and their sometimes deliberate deviations from the official figures, it is assumed that their figures are accurate. The World War II figures are based upon the official records, as reflected in the Army Almanac, and the

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*Gilbert W. Beebe and Michael E. DeBakey, Battle Casualties (Springfield, Ill.: Charles C. Thomas, 1952), p. 34.

**Albert G. Love, War Casualties (Carlisle Barracks, Pa.: Medical Field Service School, 1931); Beebe and DeBakey, op. cit.

World Almanac with some minor modifications based upon Beebe and DeBakey. The Korean War figures are based upon official data as presented in Reister; the Vietnam War data comes from Neel, Stanton, and, particularly, Thayer.*

Figure 26

Wounded to Killed Ratios in US Wars

	Ratio of Wounded to Killed	Ratio of Surviving Wounded to Battle Deaths
Mexican War	3.72	2.18
Civil War	4.55	2.38
Spanish-American War	5.88	3.94
Philippine Insurrection	3.81	2.72
World War I	5.96	4.10
World War I w/o Gas	4.20	2.88
World War II	3.57	2.41
World War II w/o USAAF	4.25	2.77
Korean War	4.02	3.56
Vietnam War	4.45	4.16

Figure 26 shows the ratios of the numbers wounded to the numbers killed in American wars of the 19th and 20th centuries and the ratio of the surviving wounded to total battle deaths, which includes those who were killed outright and those who died later because of wounds in battle. Since consistent medical

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*Army Almanac (195[illegible]); World Almanac (1985); Frank A. Reister, Battle Casualties and Medical Statistics: US Army Experience in the Korean War (Washington, D.C.: The Surgeon General, 1973); Spurgeon Neel, Medical Support of the US Army in Vietnam, 1965-1970 (Washington, D.C.: Department of the Army, 1973); Shelby L. Stanton, Vietnam Order of Battle (Washington, D.C.: US News Books, 1[illegible]); and Thomas C. Thayer, War Without Fronts (Colorado Springs, Col.: Westview Press, 1985).

records for the US Army do not exist before 1819, the first war on this list is the Mexican War, 1846-1848.

These ratios do not reveal any significant trends in relationships between wounded and killed in battles until possibly beginning in World War II. Otherwise, the relationship appears to have been fairly steady over the course of history, and certainly for most of the past two centuries.

Lethal weapons have killed one man in battle for about every four men wounded.

Of those who are hit in battle by lethal weapons appproximately three men survive for every one who dies, when those who die of wounds eventually are considered. The proportion of survivors has increased in recent wars due to modern evacuation and medical techniques.

The raw statistical data is not entirely reliable. For instance, there is reason to believe that the killed in action figures for the Union Army in the Civil War may be low, perhaps by a factor of 10% to 20%. It is possible to use official sources and arrive at very different figures for the Spanish-American War. There are two sets of numbers for wounded in action in the Vietnam War. One set includes all who were recorded at the aid stations. The other set includes only those who were evacuated from the aid stations for treatment and is 30% smaller. The lower figure is used in this handbook.

Two sets of data are shown in Figure 26 for the US experience in both World War I and World War II. This is because there were special circumstances relating to the statistics which need to be noted.

The raw data for World War I shows a ratio of wounded to killed of 5.96, which is significantly higher than in most of the other wars. This is because slightly more than one-third of the total casualties, or 72,773 casualties, were caused by poison gas. However, less than 2% of the total gas casualties were killed in action, and less than 2% of the survivors of gas injuries died of their gas-related injuries. If we deduct all of the gas-related casualties from the World War I statistics, the killed and wounded ratios for those hit by bullets or shell fragments come much closer to the values experienced in other modern combat.

In World War II the overall US Army figures show a low ratio of wounded to killed. This is because a substantial portion of the casualty figures are for the US Army Air Forces. Only a small proportion of aircraft crews survived after being shot down. Thus, the USAAF had a much lower ratio of wounded to killed than was the case for the rest of the Army. When the USAAF figures are stripped out of the totals, the US Army ground casualties for World War II are very close to the normal ground combat pattern.

The data from the Spanish-American War is particularly suspect, both because widely differing "official" statistics can be found and because the size of the sample is small compared to the Civil War and the World Wars.

Records for both the Korean War and the Vietnam War include substantial numbers of cases of individuals "Carded for Record Only," or CRO. These are individuals who were treated, but who were returned to duty immediately. These CRO cases have been omitted from the statistics shown here for those wars. There may be some relationship between this CRO phenomenon and the correlation between casualty rates and non-battle injury rates to be discussed later.

Adding to the problem for the Vietnam War was the large number of personnel missing in action, for whom data is confusing and still not complete. Those known to have died while in MIA status and those still missing are shown as having been wounded and then died of wounds. This assumption tends to degrade the effects of modern evacuation and treatment with respect to DOWs.

These are US Army figures. Including the Marine Corps casualties for our 20th Century wars, however, would make little difference. Air Force figures would be less consistent for the reason discussed above.

Impact of Improved Medical Care

Survivability on the battlefield has increased significantly as a result of the tremendous improvements that have been made in medicine in the past century. Figure 27 shows for American wars the percentage of survivors of hits, the ratio of non-battle deaths to battle deaths (KIA and DOW), and the ratio of deaths from disease to deaths from injuries.

Figure 27

US Casualty Ratios Influenced by Medical Progress

	Survivors as percent of hits	Ratio of Non-battle to battle deaths	Ratio of deaths from disease to deaths from injuries
Mexican War	69	7.30	27.80
Civil War	70	2.27	21.29
Spanish-American War*#	80	13.34	16.65
Philippine Insurrection*	73	3.15	4.59
World War I@ (w/o gas casualties)	74	1.43	11.64
World War II (ground forces only)*	73	0.36	0.28
Korean War	78	0.13	0.23
Vietnam War	76	0.24	0.24

*Ratios influenced by tropical climate
#Malaria epidemic
@Influenza epidemic

All three of the ratios shown in Figure 27 indicate that improvements in military medicine have caused a dramatic increase in survivability on the battlefield. The percentage of personnel who get hit and survive has increased since the Mexican War, and the significance of this increase is explained below. It is also evident that the proportion of total casualties caused by disease has decreased significantly.

While the trend to increased survivability is clear, the figures shown in the first column of Figure 27 might be interpreted to mean that the effect of improvements in medicine and battlefield evacuation is relatively insignificant. The chances of surviving a hit in the Mexican War and Civil War were 69 to 70 percent, and the chances of surviving a hit in the Korean and Vietnam wars were 76 to 78 percent only, a modest improvement. This comparision fails to consider, however, two fundamental attrition facts.

First, almost exactly one casualty in five (19 to 21 percent) has been killed outright in all of our wars. (The lower percent shown for the Civil War is simply one more reason for believing -- as noted earlier -- that the official Civil War statistics have omitted approximately 10,000 soldiers killed in action.)

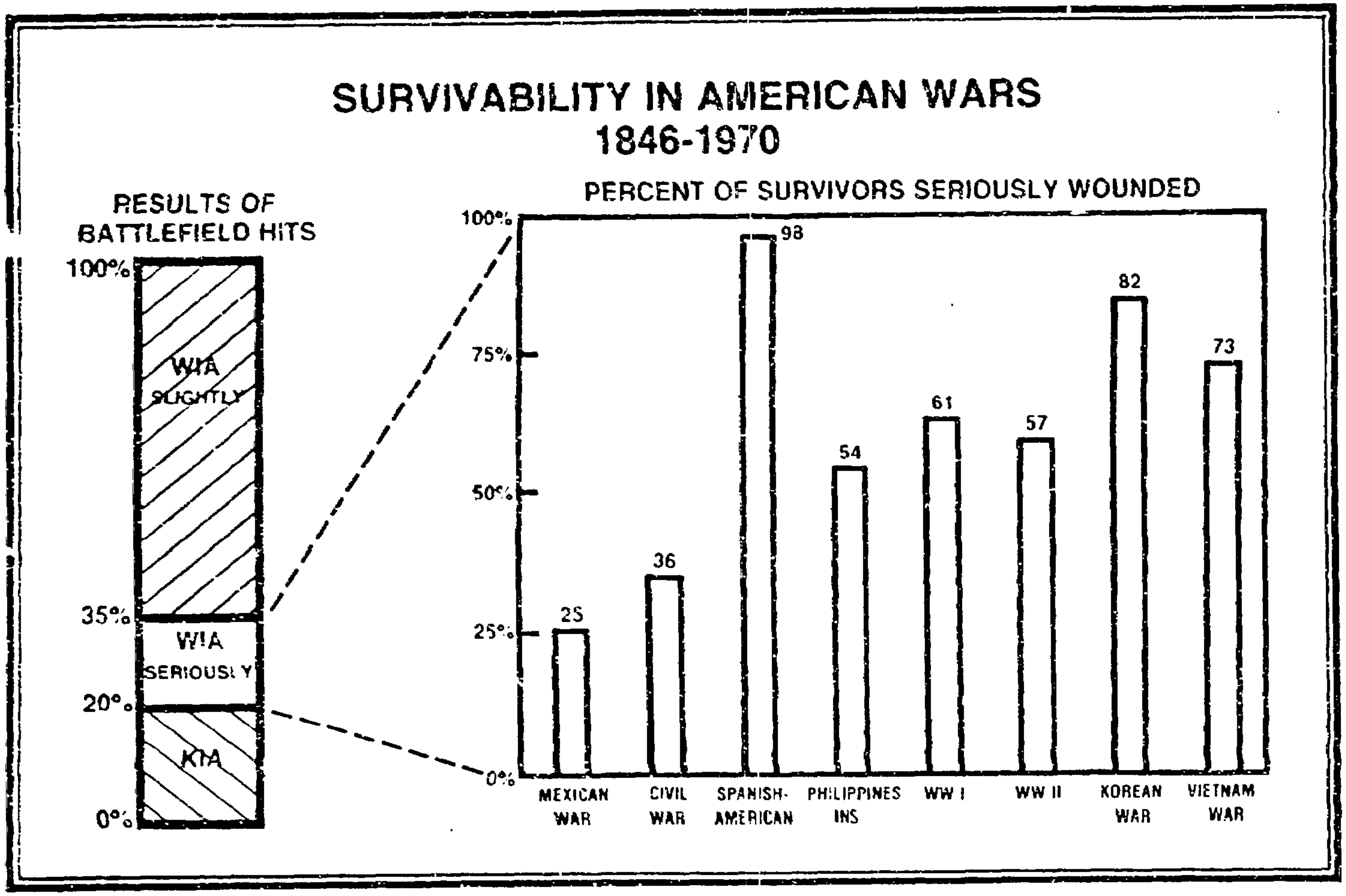
Second, approximately 65 percent of all of those hit on the battlefield suffer relatively minor wounds and will almost certainly survive even without medical attention.

This means that approximately 15 percent of those who are hit on the battlefield are seriously wounded and are likely to die without medical care. Figure 28 shows how these seriously wounded men have fared in our wars.

When the survival rate for the seriously wounded group is considered separately, the trend to greater survivability is indeed significant.

We can, as usual, discount the totally unrealistic figures for the Spanish-American War. Also, the proportion of the seriously wounded who survived in the Civil War was probably closer to 25% than 36% because of the apparent discrepancy in the KIA figures for that war. The figures for Vietnam, like those for World War II, are slightly depressed by the higher incidence of infection in tropical climates. Otherwise the trend is a dramatic testimonial to the improvements in modern medicine and battlefield evacuation. Less than a quarter of the seriously

Figure 28



SURVIVABILITY IN AMERICAN WARS
1846-1970
RESULTS OF BATTLEFIELD HITS
100%
35%
20%
0%
WIA SLIGHTLY
WIA SERIOUSLY
KIA
PERCENT OF SURVIVORS SERIOUSLY WOUNDED
100%
75%
50%
25%
0%
25
36
98
54
61
57
82
73
MEXICAN WAR
CIVIL WAR
SPANISH-AMERICAN
PHILIPPINES INS
WW I
WW II
KOREAN WAR
VIETNAM WAR

wounded survived in the Mexican War; approximately three-quarters of them survived in the Korean and Vietnam Wars.

The effects of improvements in modern medicine are also clear from the decrease in the ratios of non-battle to battle deaths and disease deaths to injury deaths from the Mexican War through the Vietnam War, also shown in Figure 27. With the exception of the Spanish-American War and the Philippine Insurrection, these ratios decrease steadily until the Vietnam War. The Spanish-American War anomaly is explained by the malaria epidemic which nearly destroyed the US Army expeditionary force in Cuba. The Philippine Insurrection figure may be understood also as an indication of a higher incidence of disease and infection in the tropics than in temperate climates. This explanation may account also for the very slight increase in the ratio of non-battle to battle dead between the Korean and Vietnam War.

Another example of the effect of improving standards of medicine in the past century is to be found in Figure 29, which shows the relationship of disease and wounds in six wars between 1854 and 1918. The relative importance of disease as a cause of casualties has declined significantly. Although the ratios are not exactly comparable, this is the same trend illustrated by the ratios of non-battle to battle deaths shown for American wars in Figure 27.

Figure 29

Ratio of Sick to Wounded in European Wars*

	Sick to Wounded Ratio
Crimean War (1854-56)	
French Army	9.06
British Army	7.90
Italian Campaign (1859)	
French Army	6.59
Austro-Prussian War (1866)	
Prussian-Army	4.67
Franco-Prussian War (1870-71)	
German Army	4.82
Russo-Japanese War (1904-05)	
Russian Army	2.37
World War I (1914-18)	
Russian Army	1.32
French Army	1.25
German Army	0.92

*Source: Great Soviet Encyclopedia (Moscow, 1928), p. 286.

Medical studies of our three most recent wars testify to the impact of improved medical care and evacuation and explain some apparent anomalies. The following quotation from Medical Support of the US Army in Vietnam explains why the survivability ratio for Vietnam was lower than for the Korean War.

> The hospital mortality rate (for wounded between January 1965 and December 1970) was 2.6 percent [for Vietnam] compared to 4.5 percent in World War II and 2.5 percent in Korea. The very slight increase in hospital

> mortality in Vietnam over that in Korea was a result of rapid helicopter evacuation which brought into the hospital mortally wounded patients who, with earlier, slower means of evacuation, would have died en route and would have been recorded as KIA (killed in action). Assuming that most of those patients who died within the first 24 hours in hospitals belong in this class, the rate would be much closer to 1 percent.*

This also is almost certainly the principal reason why there was a slightly lower proportion of survivors in World War II compared to World War I.

Finally, there is a general rule of thumb for estimating returns to duty from casualties. For each 100 personnel casualties (battle casualty, disease, or injury) 75 will be returned to duty at the end of 20 days at a rate of five per day between the 6th and 20th days after admission, and 25 will never be returned to duty as a result of death, evacuation to the Zone of the Interior, or discharge. This will vary widely from situation to situation, depending in large part upon the theater evacuation policy. It does, however, provide an initial basis for analysis of personnel attrition.

Disease and Non-Battle Injuries

Four considerations affect the disease rates of a military force: (1) the season of the year in temperate climates; (2) tropical climate; (3) quality of medical care; and (4) incidence of battle casualties.

In northern and northwestern Europe and the northern United

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*Neel, op. cit.

States, the hospital admission rate for disease is approximately twice as high in early winter (about 0.30% per day in December and January) as in summer (about 0.15% per day in June, July, and August). This seasonal variation almost disappears in subtropical and tropical regions.

In tropical climates, however, the disease rate throughout the year is approximately 1.35 times the average rate for temperate climates. In other words, if the average disease admission rate per day in a temperate climate is about 0.22%, the average rate in a tropical climate will be about 0.30% per day.

The effect of high quality, sophisticated medical care upon disease death rates is shown in Figure 27. While admissions to hospitals are not greatly affected by the quality of medical care (with the exception of the effect of malarial suppressants such as quinine and atabrine upon malaria admissions in the tropics), the length of hospital stay and the number of deaths from illness are reduced sharply when quality medical care is applied.

Regardless of the other effects upon disease rates discussed above, there is a clear and consistent correlation between disease rates and battle casualty rates in the combat zone. The following quotation from Beebe and DeBakey is relevant:

> It is of the nature of man to react with his entire being to strong stimuli. If men are placed in a combat situation their attrition is not well estimated by adding a casualty rate to their previous rates of nonbattle causes. Life under combat conditions will interfere with preventive measures otherwise considered routine and effective, will transform anxiety into somatic symptons, particularly those referrable to the gastro-intestinal and cardiovascular systems, and may bring new risks of disease and non-battle injury.

> That nonbattle attrition depends upon combat is well established, but the numerical relationship is not one which can be specified for all places and for all times. Environmental circumstances and the previous experience of the troops shape the relationship in myriad ways. The most uniform and strongest of these relationships is the correlation between wounding and psychiatric breakdown in combat troops....*

As noted in the above quotation from Beebe and DeBakey, there is also a noticeable rise in non-battle injuries (as opposed to disease) when a unit is suffering battle casualties. Otherwise, there is no apparent relationship between non-battle injuries and either disease or battle casualties. In the American wars of the 19th and 20th centuries, the hospital admission rate for non-battle injuries has been quite constant, about 0.03% per day, with deaths about 0.001% per day.

Some rules of thumb have been developed for estimating disease and non-battle injury rates in a combat theater. While these estimating rules are based mainly on US experience, they are applicable generally to all modern armies.

1. The daily non-battle loss rate for a unit not in combat in temperate climates will be as follows:

January	0.30%	May	0.18%	September	0.21%
February	0.27%	June	0.15%	October	0.24%
March	0.24%	July	0.15%	November	0.27%
April	0.21%	August	0.18%	December	0.30%

2. The daily non-battle casualty rate for a unit not in combat in a tropical climate will be 0.30%.

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*<u>Op. cit.</u>, pp. 27-28.

3. For a unit in combat, the daily non-battle casualty rate for a unit not in combat will be increased by an amount equal to 20% of the projected battle casualty rate.

Causes of Casualties

There have been major changes in the causes of casualties over the last 150 years. Prior to the middle of the 19th Century, nearly half of all casualties were caused by artillery. Then, for the three major wars of the mid-19th Century (American Civil War, Austro-Prussian War, and Franco-Prussian War) artillery caused barely ten percent of the casualties, while infantry small arms (almost entirely the conoidal bullet of the rifled musket) inflicted nearly ninety percent of the losses.

By the early 20th Century, however, the relationship of the lethality of small arms and artillery in terms of casualties caused had more than returned to the pre-Civil War situation. In fact, as shown in Figures 30 and 31, artillery and mortar shell fragments caused nearly seven out of ten WIA and DOW in World War I. The increased effectiveness of artillery was because of the ability of the artillery to fire effectively -- while out of range and observation by hostile infantrymen -- using indirect fire techniques.

Figure 30

Causes of Wounded in Action for 20th Century Wars
(US only)

Percent of WIA caused by

	Small Arms	Shell Fragments	Mines & Booby Traps	Toxic Gas	Other
World War I	19	46	-	32	3
World War I w/o gas	28	68	-	-	4
World War II	32	53	3	-	12
Korean War	33	59	4	-	4
Vietnam War	51	36	11	-	2

Figure 31

Causes of Died of Wounds in 20th Century Wars
(US only)

Percent of DOW caused by

	Small Arms	Shell Fragments	Mines & Booby Traps	Toxic Gas	Other
World War I	18	71	-	9	2
World War I w/o gas	20	78	-	-	2
World War II	20	62	4	-	14
Korean War	27	61	4	-	8
Vietnam War	16	65	15	-	4

If we assume that the proportions of those killed in action by different causative agents (for which data is not available) were approximately the same as for those dying of wounds, then the percentages of those hit by artillery or mortar shell fragments were approximately as shown in Figure 32 for the four major US wars of the 20th Century:

Figure 32

Proportion of Battle Casualties Caused by Artillery or Mortar Shell Fragments

World War I	50%
World War II	55%
Korean War	59%
Vietnam War	40%

The reason way the proportion of artillery casualties was so much higher for World War I was the reliance of the combatants upon artillery in dealing with the trench warfare stalemate of that conflict. The inability of either side to achieve major breakthroughs until near the end of the war greatly inhibited maneuver and the employment of weapons other than artillery. Since most of the toxic gas used in the war was projected by artillery shells, it could be considered that the proportion of all casualties caused by artillery in World War I was actually between 75% and 79%.

How do we explain the lower proportion of casualties caused by artillery in the Vietnam War?

World Wars I and II and the Korean War were conventional wars, fought between traditional armed forces with the most sophisticated weapons available at that time and in accordance with doctrines keyed to those weapons. The Vietnam War was a very different sort of war. The guerrilla nature of the actual combat engagements unquestionably has been overemphasized, since much of the fighting was between the conventional US and South Vietnamese armies on one side and the conventional North Vietnamese Army on the other. Unlike other wars, however, there was no front line, and the manner in which the conventional forces were employed was such that there were no large formation battles involving divisions and larger organizations. Most combat engagements were between companies and platoons. Only seldom were full battalions and brigades (or regiments) employed conventionally against each other. The engagements were relatively brief and without the lengthy artillery preparations typical of other 20th Century conventional conflicts which involved linear tactics. The Americans and South Vietnamese were supported more-or-less traditionally by a substantial amount of artillery. The North Vietnamese had a much lower proportion of artillery, although their mortar support was ample. The fact that under these conditions even as much as 40% of the casualties inflicted upon the American troops came from hostile artillery and mortars is somewhat surprising. The proportion of North Vietnamese casualties caused by US artillery was undoubtedly much higher.

Casualties by Branch of Service

Figure 33 shows the distribution of casualties among the combat arms and the non-combat services in the major US wars of the 20th Century.* A more detailed breakdown of the World War I statistics will be found in Table D, "US Army World War I Overseas Strengths and Casualties by Branch and Rank," and similar detail on World War II will be found in Table E, "US Army World War II Overseas Strengths and Casualties by Branch and Rank."

*Excepting the Vietnam War. The battle casualties of the Vietnam War have not yet been analyzed by arm/branch.

Figure 33

Percentage of Casualties by Branch for American Wars of the 20th Century

	World War I	World War II	Korea
Infantry	87.9	80.3	83.8
Armor	0.2	3.5	2.5
Artillery	4.3	5.6	6.9*
Engineer	3.2	3.6	2.4
Air Defense	-	1.9	*
Medical	1.5	2.9	3.0
Other	2.0	2.2	1.4

*Artillery and Air Defense were combined in the Korean War.

It is evident that the Infantry has suffered the highest proportion of casualties by far.

The relatively low proportion of Armor casualties in both wars may be misleading unless the reasons are explained. In World War I, tank warfare was just beginning, and only a small proportion of the AEF was in the Tank Corps. In World War II the proportion of Armor troops, and of casualties, was considerably higher in the European Theater in the closing months of the war than this average might suggest. There was relatively little use of armor in operations against the Japanese in the Pacific and Asiatic theaters. The small proportion of deployed Armor forces in the Korean and Vietnam wars is reflected also in the casualty statistics for those wars.

A better perspective on the extent to which Armor casualties could be expected in a future war in Europe can be obtained from the fact that Armor branch personnel made up only 1.4% of the average strength deployed overseas in World War II. However, the percentage of deployed Armor personnel, who were casualties in one year was 17.6%, second only to the Infantry, with 26.4% of deployed strength becoming casualties in a year.

Figure 34

Hypothetical Force and Casualty Relations by Branch

1980s and 1990s

	Percent of Theater Strength	Percent of Branch Casualties	Percent of Casualties
Infantry	15	26.0	55.0
Armor	10	18.0	27.0
Artillery	8	5.0	6.5
Engineer	10	2.0	3.5
Air Defense	12	1.0	2.0
Medical Dept.	10	2.5	3.5
Other	35	0.5	2.5

Figure 34 shows the possible general allocation of forces by principal branches in a hypothetical war in Europe in the late 1980s or 1990s. This shows Infantry troops comprising only 15% of theater forces (instead of about 22% as in World War II), Armor troops making up about 10% of the total (instead of 1.4%), and approximate allocations of the remaining 75% among Artillery, Engineers, Air Defense, Medical Department, and other branches. It is assumed that each branch will suffer approximately the same proportion of casualties as it did for World War II. On this basis the two direct fire combat arms (Infantry and Armor) would have about 82% of the total casualties, about the same as the 84% they had in World War II. But in this hypothetical war Armor troops would incur about one-third of the total Infantry-Armor casualties.

The direct fire combat arms comprise only about one-quarter of the forces deployed in a combat theater, but they incur over

80% of the casualties. The non-combat support and service arms (with the notable exception of the Medical Department) comprise about one-third of the forces deployed in a combat theater, but they incur only slightly more than 2% of the casualties. In between these groups is the Artillery, comprising somewhat less than 10% of the deployed forces and incurring somewhat more than 5% of the casualties.

Casualties by Rank

Figure 35 provides data on officer casualties in relation to enlisted casualties for American wars of the 20th Century.

Figure 35

Relationship of Officer-Enlisted Casualties
American 20th Century Wars

	Percent Officer	Percent Enlisted Men
World War I	6.6	93.4
World War II (All Army)	10.4	89.6
World War II (Less USAAF)	6.1	93.9
Korean War	5.0	95.0
Vietnam War (Killed Only)	10.9	89.1

Casualties for officers are almost directly proportional to their relative strengths in the theater of operations. In World War I, where officer leadership was exercised most conspicuously by leading troops into costly assaults against fortifications, officer casualties were substantially higher proportionately than enlisted casualties, particularly in the Infantry. In World War II officer and enlisted casualty rates in the Infantry and Armor branches were almost identical, except among lieutenants, where the officer casualty rate was considerably higher than the enlisted casualty rate. The loss rate for Artillery officers is consistently higher than that of Artillery enlisted men in both wars. This is because of the exposure of forward observers, who usually are lieutenants, to hostile aimed fire.

The breakdown of officer casualty rates by rank is shown in Figure 36, which is based on Beebe and DeBakey.* This shows clearly the high proportion of losses among lieutenants.

Figure 36

Relative Battle Casualty Rates for Officers by Rank, World War II

Rank	Percentage of Rate for all Officers
General or Field Grade	35%
Captain	53%
First Lieutenant	105%
Second Lieutenant	204%
Warrant Officer	8%

The rates and relationships for casualties which have been discussed in this chapter and the preceeding chapter have all been based on data from major conventional wars. In the 20th Century these major wars have included large forces engaged in more or less continuous combat over large areas. The major conventional wars did include smaller military operations, such as raids and rescues, and they did include rebellions, guerrilla warfare, and insurgencies. However, the casualty experience from these lesser forms of combat has been lost in the overall casualty data which has emphasized primarily combat between two large "regular" armies. In order to provide some understanding

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*_Op. cit._, p. 46.

of these lesser forms of conflict, the next chapter treats casualty experience for selected engagements from less than major wars since 1945.

Chapter 5

PERSONNEL ATTRITION: MINOR CONFLICTS SINCE 1945*

There have been no major wars since 1945, but there have been a large number of lesser conflicts. A few of these lesser conflicts were significant regional wars, such as the Korean War, the Arab-Israeli Wars, the Iran-Iraq War, and, in its later stages, the Vietnam War. However, a large number of these post-1945 conflicts have been relatively minor conflicts, such as raids, rescues, inverventions, or insurgencies.**

These less than major wars have flourished because of nuclear deterrence, superpower rivalry, and Third World instability. The existence of relatively balanced nuclear forces discourages the US and the USSR from direct confrontation and major war. Although this mutual deterrence discourages major wars between nuclear powers, it appears to have encouraged the lesser forms of warfare. In this climate, the USSR has encouraged wars of national liberation designed to spread Soviet influence by taking advantage of poverty and discontent in less developed nations. Economic problems coupled with political authoritarianism in some of these nations has brought about a large number of insurgencies, rebellions, and minor hostilities.

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*This chapter is based on HERO Report No. 118, Casualty Estimates for Contingencies (Fairfax, Va.: HERO, 1986).

** HERO has tentatively identified 300 post-1945 conflicts. This list is being refined, and the number of conflicts will change as a result of this process. A complete list of these conflicts with some descriptive information about each conflict will be published by HERO in 1986.

These minor conflicts are likely to continue to occur in the future. It is important, therefore, to understand how the attrition experience in minor conflicts compares with the rates and relationships experienced in major conventional warfare, such as World War II.

Classification of Post-1945 Conflicts

In order to establish a basis for research into casualty experience in these minor conflicts since 1945, HERO examined a sample of 48 post-1945 conflicts and classified them into four groups. This was accomplished by plotting the 48 sample conflicts by intensity and duration. The duration of the conflicts ranged from one day to over 25 years. The operations were assigned to one of four intensity categories as shown in Figure 37.

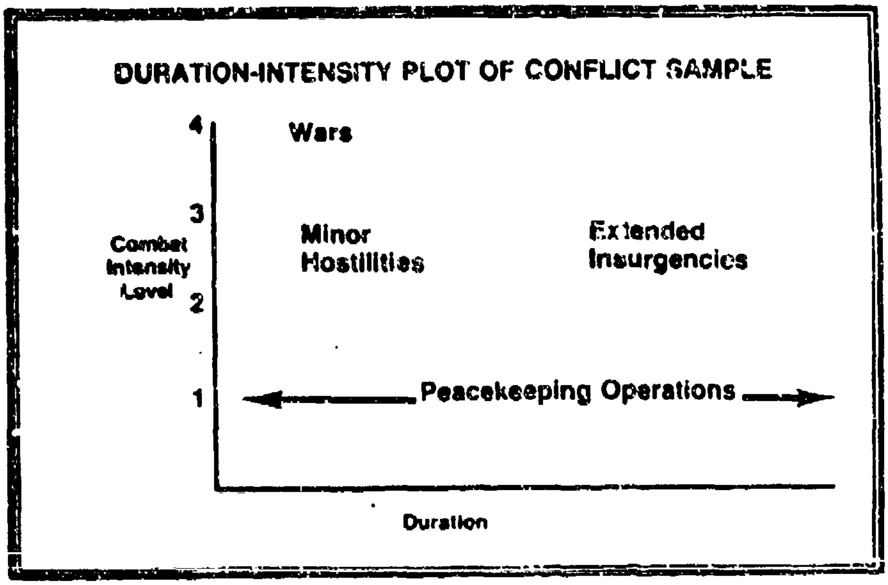
Figure 37

Combat Intensity Levels

Combat Intensity Level 1:	Absence of combat but occasional inadvertent violence.
Combat Intensity Level 2:	Sporadic and intermittent combat involving small numbers of combatants.
Combat Intensity Level 3:	Frequent combat involving large groups of combatants with relatively few pauses and periods of intense combat.
Combat Intensity Level 4:	Continuous combat involving large groups of combatants with relatively few pauses without some combat activity.

The plot revealed some definite groupings which were helpful in understanding the nature of post-1945 warfare. Figure 38 is a schematic of plotted points. Four groups emerge clearly.

Figure 38



There was a distinct group of operations without sustained violence or combat and with various durations. These were peacekeeping operations and shows of force in which combat had not been intended but in which violence may have occurred inadvertently.

There was a significant group of conflicts which had involved sustained combat short of conventional war and which had long durations (all had lasted over one year and many had lasted five years or more). These were insurgencies which were successful enough to last beyond the initial stages. They were called extended insurgencies.

There was a small group of fairly short duration, high intensity operations. These were wars, such as two of the Arab-Israeli Wars and one India-Pakistan War.

Finally, there was a group of operations clustered at intensity levels 2 and 3 and of relatively short duration. These were a conglomerate group of different types of operations: raids; interventions; rescue missions; abortive rebellions, and brief (mostly failed) insurgencies. The major characteristic of these operations was that they were constrained in scope, participants, and duration. They often led to decisive results. These were called minor hostilities.

The 73-Engagement Data Base

The classification scheme for minor conflicts was used as a guide to perform detailed research on casualty experience. A sample of 81 engagements was researched. Subsequently, six engagements were omitted from the final sample for analysis because insufficient casualty data was available to permit a full analysis. Two other engagements were omitted because they involved mass capitulations and biased the CMIA data. The final sample used for analysis has the composition shown in Figure 39.

Figure 39

Composition of 73-Engagement Data Base

	Engagements from:			
	Small Wars	Extended Insurgencies	Minor Hostilities	Total
81-Engagement Data Base	23	31	27	81
Poor Casualty Data	-3	-3	0	-6
Mass Capitulations	0	0	-2	-2
73-Engagement Data Base	20	28	25	73

The 73-Engagement Data Base was compiled to provide insights on casualties suffered by sophisticated, modern armed forces engaged in minor conflicts. Casualty data was collected only for the "modern" Western-type forces. Conflicts which did not include the US or its allies were excluded. Conflicts in Europe and Northeast Asia were also excluded. The US experience in Vietnam was excluded, although engagements involving Australian and New Zealand forces in Vietnam were included. The intent was to analyze engagements which were representative of the kind of minor conflicts in which the US itself might become involved. The combat engagement was selected as the unit of analysis to permit identification of casualty experience during actual combat.

The 73-Engagement Data Base provides reasonably good information on the eight variable factors affecting combat shown in Figure 40.

Figure 40

Circumstantial Variables for Casualty Rate Analysis

Terrain
Weather
Surprise
Posture
Air Superiority
Insertion Means
Opposition to Insertion
Organizational Type

The 73-Engagement Data Base does provide accurate information on casualties by kind. It is possible to differentiate among KIA, WIA, and CMIA, and the sum of these three, Total Battle Casualties (TBC). Except for US data there is no distinction between KIA and died of wounds (DOW), and the KIA figures include DOW. The 73-Engagement Data Base does not, however, provide useful information on grade, branch, or role (combat vs. support) of the casualties.

From an analytical viewpoint, the 73-Engagement Data base has some imperfections. It is neither random nor representative. It is small compared to the total number of combat engagements (8,000 plus) estimated to have occurred in conflicts since 1945. While the sample size does meet the minimum size to assume, for statistical analysis, an underlying normal distribution, it would be better if a larger sample were available. The casualty data is widely dispersed, and the means of the various sub-samples are not particularly useful to describe the casualty experience. However, the 73-Engagement Data Base appears to be homogeneous enough to warrant using it as a whole, and it is the only data base currently available for analysis of casualty experience in post-1945 minor conflicts. A complete list of the 73-Engagement Data Base is in Appendix 5.

Analysis of Engagement Data

The mean daily casualty rates for TBC, KIA, WIA, and CMIA for the 73 engagements are shown in Figure 41.

Figure 41

Casualty Rates from the 73-Engagement Data Base

	Mean Daily Casualty Rate - %			
	TBC	KIA	WIA	CMIA
Mean Rates	2.6	0.6	1.8	0.2

In the sample, 22% of the casualties were KIA; 70% were WIA; and 8% were CMIA. The ratio of WIA to KIA is 3.76.

Casualty Rates versus Unit Strength

The data on Total Battle Casualties was analyzed with respect to both strength and duration. With respect to unit strength, the findings are shown in Figure 42.

Figure 42

Total Battle Casualty Rates by Unit Strength

Unit Strength Class	Number of Engagements N	Mean Daily Casualty Rate %
less than 300	14	5.0
301-600	15	3.2
601-1,000	13	2.3
1,001-2,500	17	1.3
over 2,500	14	1.2

The casualty rates in the 73-Engagement Data Base show the same relationship between strength and size as has been experienced in more extended combat in major wars. The smaller the unit, the higher the casualty rate. This relation obviously goes beyond the geometry of exposure to the phenomenon which has been described above as "friction in combat." Regardless of the explanation, the effect is real and occurs consistently in all combat.

Casualty Rate versus Duration

Figure 43 shows the relationship between total battle casualties for various classes of engagement duration.

Figure 43

Total Battle Casualty Ratios by Engagement Duration

Duration Class (Days)	Number of Engagements N	Mean Daily Casualty Rate %
1	37	3.8
2	13	2.3
3 - 5	8	1.3
6 - 10	8	0.8
Over 10	7	0.1

An interesting variation is achieved if a different criterion is applied to assignment of duration for short engagements. The original rule for the sample was to assign a duration of one day for all engagements lasting a part of a day. If a finer screen is used to permit an engagement duration of a half day, the results are somewhat different. For each engagement whose duration is reassigned from one day to a half day or from two days to one day, the daily casualty rate doubles. Figure 44 shows the difference for the 73-engagement sample when this reclassification is accomplished.

Figure 44

Total Battle Casualty Rates by Alternative Duration Classes

Duration Class (days)	Number of Engagements N	Mean Daily Casualty Rate %
1/2	36	7.1
1	8	4.3
2	6	3.1
3 - 5	8	1.3
6 - 10	8	0.8
Over 10	7	0.1

For both of these data sets, there is a definite relationship between duration and casualty rates. The longer the engagement the lower the rate. This effect is most pronounced for the engagements longer than five-days (which probably should not have been classified as engagements in any case). For an engagement of five days or less, the casualty rates still are higher for a one-day engagement than for a five-day engagement. Whether this means also that rates are higher on the first day of a multi-day engagement than on subsequent days cannot be inferred with confidence from this data sample.

The value of placing a finer screen to develop the alternative duration array is questionable. War functions on a daily basis. The basic reports are daily reports; support activities operate on a daily basis; and planners think in terms of days. The very short engagements which were classified as lasting a half day were all concluded in that same day. As far as medical care or replacements are concerned, it does not matter whether the rates were for a half day or a day. From the planners' viewpoint that engagement lasted a day, even if it was all over from the participants' viewpoint in a few minutes or hours. Commanders and staffs cannot forecast the length of the engagement in advance and must estimate the number of "days" of medical support and replacements to be provided in any case.

Captured/Missing in Action

Data on CMIA from the 73-Engagement Data Base is important because such data is not normally available in much detail at levels below divisions. The overall CMIA proportion of the total casualties is 2.7%, and CMIA were reported in only 9 of the 73 engagements. These nine engagements do not display any definite pattern of influence by any circumstantial variable. No CMIA were reported for 64 of these engagements.

Two engagments which were omitted from the 73-Engagement Data Base do show large numbers of CMIA. These were the Indian Invasion of Goa in 1961 and the Bay of Pigs Invasion, also in 1961. In the Goa invasion, 1,189 CMIA were reported out of total battle casualties of 1,303; this CMIA figure includes the WIA also. At the Bay of Pigs, the CMIA were 4,801 of 4,888 total battle casualties, all out of a strength of 7,195. In both of these cases the CMIA figures resulted from a massive capitulation of one side.

Overall, CMIA does not appear to be a major or a consistent factor in these kinds of engagements. This may be partly because CMIA are not reported, or it might be because the less sophisticated force either does not take or does not keep prisoners. A major reason, however, may be that the modern forces engaged in these relatively short combat operations consist of well trained professionals who do not operate in such a way as to incur a large number of prisoners or MIA.

Casualties by Circumstances of Combat

In order to provide casualty rates for various sets of combat circumstances, the 73 engagements were classified according to the eight circumstantial variables shown in Figure 40. Total Battle Casualty (TBC) rates were calculated for each of the types of engagement within each category. The results are presented in Figure 45. Three numbers are given in Figure 45 for the sophisticated forces in each engagement category: the number of engagements in a particular class; the mean daily total battle casualty rate; and the ratio of wounded to killed.

Figure 45

Casualty Data by Circumstantial Variables

Terrain Type	Number of Engagements	Mean Daily TBC Rate %	Wounded to Killed Ratio
Flat	17	3.8	3.44
Rolling	16	2.1	3.41
Rugged	21	2.0	3.94
Urban	19	2.5	4.09
Weather Type			
Cold	6	3.0	3.54
Temperate	23	3.6	3.66
Hot	44	2.0	3.99
Surprise			
Surprising	20	1.5	2.87
No Surprise	43	2.1	4.25
Being Surprised	10	6.6	3.10
Posture			
Attack	60	2.4	3.84
Defend	13	3.3	3.55
Air Superiority			
Superiority	47	2.5	3.82
No Superiority	26	2.8	3.64
Insertion Means			
Overland	51	2.2	3.81
Parachute	9	2.3	2.30
Air Landing	4	0.6	3.00
Helicopter	4	7.7	1.47
Ship	2	*	0
Unknown	3	7.1	6.50
Opposition to Initial Entry			
Opposed	58	2.7	3.84
Unopposed	12	0.8	1.74
Unknown	3	7.1	6.50
Organizational Type			
Foot	4	5.4	3.76
Foot, Motor-Mech	5	1.9	3.53
Motor-Mech w/armor	37	2.4	3.87
Airborne	24	2.4	3.32
Special Operations	3	2.6	1.50

*Less than 0.5%

Daily Engagement Total Battle Casualty rates do vary from the mean when related to the eight circumstantial factors. The mean TBC daily engagement casualty rate for the entire sample is 2.6% per day. Casualty rates below 1.8% or above 3.4% are considered to vary significantly from the mean. On this basis, the sample shows the following with respect to engagement casualty rates:

o Terrain exercises a slight but clear effect on the casualty rates. The rate for flat terrain is significantly higher than the mean, presumably due to lack of cover and concealment. The effect of rugged terrain in reducing the casualty rate is large but not necessarily significant.

o Weather has some effect. The mean casualty rate for engagements in hot weather is lower than the mean for the entire sample, and this is consistent with experience in major wars. Although the mean for engagements in cold weather is higher than the sample mean, the number of cold weather engagements is too small to permit drawing a definite conclusion from this.

o Surprise has a great effect on casualty rates. When one side achieves surprise on the other side, the casualty rate for the side being surprised is significantly higher than the mean. This means that forces entering on this kind of military operation must take due precaution against being surprised. When the one side achieves surprise, its casualty rates are significantly lower than the mean. Surprise is a major factor affecting casualty rates in this kind of operation.

o Posture has an effect on casualty rates. The mean casualty rate for forces in defense is higher than the mean rate for forces in the attack. Three of the 13 defensive engagements were ambushes, and two were Argentine air attacks on British ground forces in the Falklands in which the British had very high casualty rates. Only three of the 13 defensive engagements had rates below Ø.5%. One enduring feature of historical combat is that the defender's casualty rates have been higher than the attacker's casualty rates. This data suggests that the defender's tendency to have higher casualty rates is true of these minor conflict engagements as well.

o Air Superiority was not a factor in sophisticated force casualties whether the sophisticated force had it or not. There were no engagements in this sample in which the less sophisticated force had air superiority, and so the impact of effective air attack on sophisticated force casualty rates has not been measured.

o Means of Initial Entry into the engagement does show some significant differences in casualty rates. Entry by helicopter leads to significantly higher than average casualty rates, but the mean of this small sample is influenced a great deal by the Mayaguez Incident in which there were numerous casualties from a single helicopter crash. Entry by air landing demonstrates significantly lower than average casualty rates. Although the sample is very small, it is apparent that entry by ship was a particularly safe method.

o Opposition to entry is also a factor. Achieving unopposed entry led to significantly lower casualty rates than entering in the face of active opposition. This is related to the desirability of achieving surprise.

o Organization Type does not appear to have an impact on casualty rates. The mean rate of all groups are close to the sample mean rate except for organizations in which foot elements were predominant. Eight of the nine engagements in which foot elements participated took place in 1945 and 1946 in Indochina and Greece, and these had high daily casualty rates. Airborne units were used in 24 engagements which involved 9 parachute assaults and 3 air landings. Airborne units may be used in contingency operations because of their elite status as well as their special qualifications. Most units involved in this kind of operation are motorized or mechanized infantry with some armor, and the results of this analysis suggest that having some form of vehicular mobility is desirable.

The Wounded to Killed Ratio

Another statistic of interest is the ratio of wounded in action to killed in action. The wounded to killed ratio for the entire sample of 73 engagements is 3.76. This is consistent with experience in combat engagements in major wars since 1840. There are some variations with respect to the circumstances of combat which are worthy of note. The variation in the wounded to killed ratio is considered significant for values above 4.50 and below 3.00.

o Terrain, Weather, Posture, and Air Superiority do not have significant impact on the wounded to killed ratio.

o Surprise does have an impact on the wounded to killed ratio. When forces achieve surprise they have a significantly lower wounded to killed ratio than otherwise.

o <u>Insertion Means</u> does show some variation in the wounded to killed ratio. Both parachute assault and helicopter entry show significantly lower than average wounded to killed ratios; this means that a much higher proportion of casualties in these kinds of entries are killed outright than is usual.

o <u>Opposition to Insertion</u> does have an impact on the wounded to killed ratio. When entry is unopposed, the wounded to killed ratio is significantly lower than the overall ratio.

The wounded to killed ratio is affected much less by the circumstances of the combat than is the casualty rate itself. Under most conditions, it can be expected that three to four wounded will occur for each KIA.

Composite Terrain & Weather Casualty Rate Matrix

The tendencies of casualty rates to vary according to the various circumstantial factors are different if the effects of more than one factor are combined. Unfortunately, the 73 engagement data base does not provide a large enough sample to be able to do this for all of the eight factors evaluated. It is possible, however, to combine two factors to produce a composite matrix.

Terrain and weather are two important factors in planning or interpretation of this kind of combat. The terrain and weather matrix combines two of the environmental factors which are determined primarily by the location of the engagement. For an actual or projected engagement the terrain and weather can be predicted very well, and so can the average casualty rates to be expected (provided the engagement sample is a good predictor).

Figure 46 shows the format of the terrain and weather matrix and the number of engagements in each cell. The number of engagements in each cell is not very large, and some cells have too few engagements upon which to base valid conclusions about future rates under similar circumstances.

Figure 46

Cell Sizes for Terrain & Weather Composite Casualty Rate Matrix

TERRAIN	WEATHER		
	Hot	Temperate	Cold
Flat	13	4	0
Rolling	12	1	3
Rugged	8	10	3
Urban	11	8	0

The mean daily total battle casualty rates for each combination of terrain and weather are shown in Figure 47.

Figure 47

Mean TBC Rates for Terrain and Weather Composite Matrix
(% per day)

TERRAIN	WEATHER		
	Hot	Temperate	Cold
Flat	2.6	7.4 (1.9)	-
Rolling	1.6	3.3	3.6
Rugged	0.6	3.0	2.4
Urban	2.5	2.5	-

The mean rate for engagements in the Flat-Temperate cell is distorted by a single engagment (the Mayaguez Incident) in which the casualty rate was 23.5% per day. Omitting this one engagement produces a mean rate for the cell of 1.9% per day. Neither value is probably representative of this combination because of the small number of engagements available to compute the values.

Values of the mean TBC rate for other cells appear to be close to the total mean rate of 2.6%, except for the Rugged-Hot and Rolling-Hot cells. The low rates for these two cells is consistent with evidence from other combat that preoccupation with personal survival and operating in a hostile environment results in lower than average casualty rates for both sides. In these cases the hot climate itself tends to mitigate against aggressive action, and the impact of the rugged terrain lowers the casualty rates further.

This matrix, and others like it for other variables, can be very helpful in planning or interpreting engagements from minor hostilities or from certain stages of extended insurgencies. The data from the 73-Engagement Data Base is sufficient to prove the validity of the method but insufficient to provide high confidence that the rates experienced are representative of future engagements.

Comparison With World War II Casualty Rates

In order to compare casualty rates for the 73-Engagement Data Base with casualty rates from World War II, two conditions must be fulfilled:

1. The comparison must be made for units of the same approximate size. This is because casualty rates vary according to the strength of the unit.

2. The comparision must be made with casualty rates for engagements rather than for months or years of experience. The US daily casualty rate for all ground forces during World War II was about 0.05% per day. This is much lower than typical engagement casualty rates because it includes many days in which units were not in combat. The engagement casualty rate, which includes only days in which the units were in active combat, was about 1.0% per day for divisions.

Figure 48 shows daily engagement casualty rates for the 73-Engagement Data Dase compared with average rates for World War II, arranged by approximate unit size.

Figure 48

Comparison of WWII and Minor Conflict Casualty Rates

Unit Size	World War II Percent	Minor Contingencies Percent
Company	-	5.0
Battalion	8.0	2.3
Brigade	2.9	1.3
Division	1.0	-

The difference in rates appears at the battalion and brigade level where the two samples overlap. On the basis of this data it appears that daily engagement casualty rates for minor contingencies are from one-third to one-half the equivalent rates experienced in sustained combat in World War II.

This result may be due to several conditions. One reason may be that the casualty data for the minor contingencies is for US and similarly modern, sophisticated forces fighting less sophisticated forces from less developed nations. On this basis, the Combat Effectiveness Value of the sophisticated forces should exceed that of the opposing forces. In general, forces with higher combat effectiveness have fewer casualties than forces of their inferior opponents.

Another related factor is that the sophisticated forces in these kinds of operations usually did not face the kind of artillery fire that was common during sustained combat in World War II. Most of the weapons on both sides in the minor contingency engagements were small arms, with some tanks and some mortars. Artillery is a major cause of casualties in modern combat, and its absence would tend to lower battle casualty rates.

Still another possible explanation of the much lower casualty rates for minor conflicts is that many of these operations are short and decisive, without the kind of sustained combat that existed during the more or less continuous campaigns and battles of World War II.

Whatever the explanation, the evidence of this comparison is that daily engagement casualty rates for minor conflicts have been much smaller that they were during World War II.

There were no other significant differences between the casualty rates for the minor contingencies and those for World War II. The manner in which the eight circumstantial variables affect the rates appears to be quite similar, and the wounded to killed ratio is about the same for both sets of data.

Summary of Casualty Experience for Minor Conflicts

The analysis of the 73 engagements taken from conflicts post-1945 indicates that casualties and casualty rates from this kind of combat are very similar to those from combat in major wars. The major lessons are as follows:

-- A company or battalion-sized unit involved in a minor conflict can expect to have an total battle casualty engagement rate of 3.5% per day or less. Casualty rates larger than this are possible, but they will be due to catastrophic events rather that "normal" conflict.

-- Between three and four personnel will be wounded for each person killed.

-- Lower than average rates will be experienced in hot climates, rugged terrain, or both.

-- Achieving surprise will reduce casualty rates by half; being surprised will increase casualty rates by a factor of three.

-- Higher than average casualty rates can be expected when an initial insertion by helicopter or parachute assault is opposed.

-- Captured and missing in action personnel are not a major factor in this kind of operation provided unit discipline is good and mass capitulation does not occur.

-- Estimation of expected casualty rates during planning for minor conflicts can be facilitated by taking into account the expected environmental and operational factors of the operation and the relative combat effectiveness of the two sides.

Chapter 6

MATERIEL ATTRITION

Materiel attrition has become a major factor in combat only in the last 150 years. Before the middle of the 19th Century non-personnel attrition in combat was significant only for horses and artillery guns, and the vast majority of gun attrition was due to overrun and abandonment to the enemy rather than destruction by hostile fire. Supply was as important to military operations before the 20th Century as it has been since, but it was provided from what the soldier carried on his person or packed on beasts of burden and in animal-drawn wagons. This is not to say that losses of animals, weapons, and other war materiel were not important. They were, but their significance was less before the Industrial Revolution than after.

Introduction to Materiel Attrition

From a military standpoint, the first major technological contribution of the Industrial Revolution was the application of steam energy to railroads and steamboats early in the 19th Century. The new steam engine technology had some impact on the Crimean War, but the American Civil War was the first major conflict in which the impact was profound. Many historians attribute Northern superiority in both rail and steamboat resources as a fundamental factor in the Confederacy's defeat.

The next important contribution of technology to warfare was the conoidal bullet, whose effects are discussed in Chapter 2.

This was followed about thirty years later by the automobile, propelled by an internal combustion engine. Although this technology was not exploited sufficiently to prevent the static trench warfare of World War I, that conflict saw the introduction of many weapons based on this engine -- the tank, the combat aircraft, trucks and tractors to tow artillery, and rudimentary self-propelled artillery. A greatly enhanced logistics potential also resulted from the development of the internal combustion engine. A generation later the Germans combined these new developments into blitzkrieg, which became the model for the conduct of conventional war by all major powers.

With the increasing importance of these materiel means of waging and supporting war, it became important to target the opposing force's weapons and equipment, in many cases in preference to targeting his personnel. In modern ground warfare, therefore, materiel attrition has become almost as important as personnel attrition.

Despite the increasing importance of weapons, vehicles, electronic equipment, and other materiel in the conduct of modern war, there has been less systematic analysis of the historical experience of materiel attrition than of personnel attrition. This is not because of lack of data. Considerable data on damage and destruction of materiel items is in unit records and in supply records, to include the actions taken to repair or replace the items damaged or destroyed. However, little effort has been made to extract, organize, and analyze this wealth of data. It has been possible to ascertain general patterns in materiel losses in the American wars of the 20th Century from fragmentary reports and data compilations. Even though these patterns and relationships are less well-defined and less substantiated by documentary evidence than are personnel attrition patterns, they provide valuable insights on materiel attrition in modern combat.

One important insight is that materiel losses in combat are related to personnel casualties. When personnel casualties in battle are high, so too are losses of tanks, guns, trucks, and other items of materiel. In general, these are proportional relationships.

Data in this handbook has been taken mostly from World War II and the 1973 Arab-Israeli War for tank and artillery losses. Helicopter loss data is from the Vietnam War.

The rest of this chapter presents attrition information on tanks, artillery, helicopters, and other equipment. Most of the chapter deals with tank losses, as this is the area of materiel attrition that has been emphasized the most. The treatment of tank losses discusses tank losses and the relationship of tank losses to personnel casualties at various levels of aggregation, proceeding from the individual tank, to the armored battalion/regiment, to the armored division, and, finally, to formations involved in large engagements and operations. The chronological and geographical treatment comprehends World War II (US, British, and Germans on the Western Front; German and Soviet experience on the Eastern Front) and the 1973 Arab-Israeli War. The artillery loss section relates artillery weapon losses to personnel casualties in a manner similar to that used to develop the tank loss relationship. Helicopter losses are addressed as well as the scarce data permits. Finally, a brief comment is made on the relatively unexplored area of losses of materiel other than tanks and artillery, and helicopters.

Tank Losses and Crew Casualties

Analysis of the relationship of tank losses to crew casualties is based on data from field reports of the US First Army for combat operations from June 1944 through April 1945. Data is provided on 898 tanks (797 medium and 101 light) rendered inoperable by enemy action. The data show the tank losses by cause and distinguish whether the tanks burned or not. The incidence of tank crew casualties is shown in relation to tank losses by cause of loss, by crew position, and according to whether the tanks lost burned or not.

Figure 49

Tank Losses and Crew Casualties by Cause
(First US Army, June 1944 - April 1945)

Cause of Tank Loss	Tank Losses	Crew Casualties	Crew Casualties Per Tank Loss	Crew Casualties as % of Total Crew
Mine	171	73	0.43	9%
Antitank Rocket	119	190	1.60	33%
Gunfire	502	579	1.15	24%
Unknown	106	36	0.34	7%
	898	878	0.98	20%

Figure 49 shows tank losses and crew casualties by cause of tank loss. There was almost one casualty (on the average) for each tank lost. The largest cause of casualties to both tanks and crews was gunfire, causing 56% of tank losses and 66% of personnel casualties. There is some evidence that artillery caused about 50% of these gunfire losses, tank guns caused about 30%, and antitank guns about 20%. Although 20% of the tanks were damaged or destroyed by mines, only about 9% of the personnel casualties were from that cause. By contrast, the antitank rocket (bazooka) caused about 13% of the tank losses and about 21% of the personnel casualties, making an average of 1.60 casualties in each tank damaged by that weapon.

Figure 50 shows the distribution of casualties by crew position. The casualties were distributed evenly among the crew members.

Figure 50

Tank Crew Casualties by Crew Position
(US First Army, June 1944 - April 1945)

Crew Position	Casualties	Percentage of Casualties
Commander	196	22
Gunner	184	21
Driver	173	20
Bow Gunner	179	20
Cannoneer*	146	17
	878	100

*This number is reduced because the 101 light tanks in the sample did not have a cannoneer.

Figure 51 shows an interesting relation between personnel casualties in tanks that burned and those in tanks that did not. Over 60% of the tanks that were hit did not burn. About half the casualties were in tanks that burned, and the other half were in tanks that did not. In tanks that burned, however, the crew casualty rate was significantly higher than in tanks that did not burn.

Figure 51

Impact of Tank Burning on Crew Casualties

Tank Loss Type	Tank Losses	Total Crew	Crew Casualties	Casualties as % of Crew	Crew Casualties Per Loss
Burned	346	1,695	444	26	1.28
Not Burned	552	2,694	434	16	0.78
TOTAL	898	4,389	878		

Tank Losses and Casualties in Battalion-Sized Maneuver Units

The relationship described in the previous section between tank losses and tank crew casualties is an obvious one. The relationship between tank losses and personnel casualties in entire battalion-sized armored units is not so obvious but still very real. The statistic used to demonstrate this relationship is the ratio of tank losses to personnel casualties, when both are expressed as rates. There are two samples used to illustrate this point. One sample is based on the experience of four US tank units during a period from late July 1944 until May 1945. The other sample is based on the experience of four British armored regiments in a three-day engagement in July 1944. The ratio of tank loss rate to casualty rate is computed for each of these units. The data is shown in Figures 52 and 53.

Figure 52

Armored Battalion Tank Loss and Personnel Casualty Rates (US 6th Armored Division, July 194[illegible] – May 1945)

	Personnel		Tanks		
	Casualties	Casualty Rate	Losses	Loss Rate	Ratio of Tank Loss Rate to Casualty Rate
15th Tank Battalion*	411	55%	129	256%	4.65
68th Tank Battalion*	297	40%	101	202%	5.05
69th Tank Battalion*	422	56%	91	182%	3.25
86th Cav. Rcn. Sq. (Mecz)**	426	45%	20	118%	2.62

*Based on the TO&E strength of 751 personnel and an average strength of 50 medium tanks.

**Based on TO&E strength of 949 personnel and 17 light tanks.

Figure 53

British Armored Regiment Tank Loss and Personnel Casualty Rates
(Operation Goodwood, 18-20 July 1944)

	Personnel		Tanks		
	Casualties	Casualty Rate	Losses	Loss Rate	Ratio of Tank Loss Rate to Casualty Rate
2d Norfolk Yeomanry	50	7.55%	37	51.39%	6.81
8th Hussars	1	0.14%	2	2.73%	19.84
2d Welsh Guards	13	1.86%	15	22.06%	11.86
148th RAC	6	0.91%	1	1.43%	1.57
	70		55		

This sample of only eight units is insufficient to permit an inference that the population of battalion-sized armored units would exhibit the same relationship. However, the ratio of tank loss rates to casualty rates for these eight data points show some consistency, with a mean of 6.96 and a standard deviation of 6.10. The values of the ratios all fall reasonably close to the mean, except for the 8th Hussars which had only one personnel casualty in three days of fighting.

Additional research is necessary to establish to a higher degree of confidence the validity and relevance of this ratio. However, this step does provide a transition to the next level of the analysis, which is to examine the same relationship between tank losses and personnel casualties for entire armored divisions.

US Armored Division Casualty and Tank Loss Rates

Relating armored division casualty rates to tank loss rates provides an indication of combined arms losses in armored combat, since armored divisions contain sizable artillery and infantry components. There were two types of US armored divisions in World War II, heavy and light. Only the 2d and 3d were heavy, with an authorized strength of 14,500 men, and 232 medium and about 130 light tanks. Other US armored divisions in Northwest Europe were light, with 10,900 men and 168 medium and 77 light tanks authorized. As a result of the heavy initial losses suffered during the Normandy invasion, the armored divisions, and indeed all tank units, were rarely up to strength. Figure 54 shows casualty and tank loss data for two light armored divisions in combat in Europe in November and December 1944.

US infantry divisions in World War II did not have organic tank battalions. A non-divisional tank battalion was normally attached to an infantry division, and its tank platoons were attached in turn to the infantry battalions. These tanks were used tactically for infantry support rather than in mass, and there was a very high ratio of infantry personnel to tanks. The ratio of tank loss rates to personnel casualty rates in World War II infantry divisions was about half that experienced in armored divisions.

Figure 54

Armored Division Casualties and Tank Losses
(US Armored Divisions, Nov-Dec 1944)

Divison and Time Period	Personnel Casualties	Average Daily Casualty Rate	Tank Losses	Average Daily Tank Loss Rate	Ratio of Tank Loss Rate to Casualty Rate
6th Armored Div. (28 days)	986	0.32%	108	1.64%	5.12
4th Armored Div. (30 days)	1,416	0.46%	173	2.64%	5.35

The US 6th Armored Division data is for a 28-day period of combat 10 November to 7 December 1944, when the division was attacking in Lorraine. The division launched an attack on 10 November and was engaged in combat continuously (although not always intensively) until 29 November. A part of the division attacked again on 4 December and continued in action until the 7th. During periods of intensive combat both casualty and tank loss rates were higher than the average over the entire period. The highest percent personnel casualties for a single day was 1.04% on 15 November. The average daily loss rate for the 19 days of the attack from 10 November to 28 November was 0.45%. The daily tank loss rate exceeded 3% on each of the first four days of the attack, with a high single-day rate of 4.83%. The average for this same attack period was 2.15% per day, for a ratio of tank loss rate to casualty rate of 4.78.

The 4th Armored Division data is based on experience for 30 days in combat from 8 November to 7 December 1944. In the week of 12 to 18 November, during which the division was involved in particularly heavy fighting, the casualty rate was 0.84% per day, and the tank loss rate was 4.29% per day. There were 9.31 casualties per tank loss, and the ratio of tank loss rate to personnel casualty rates during that week was 5.11 to 1.

The ratio of tank loss rates to personnel casualty rates are very similar for these two US armored divisions. The divisions were fighting in the same weather and terrain, and this contributes to the similarity of the results. Even so, the consistency of the results suggests a definite relationship between personnel casualties and tank losses.

British Casualty and Tank Loss Rates in Operation Goodwood

In July 1944 the British I and VIII and Canadian I Corps participated in a particularly intensive operation, code-named "Goodwood." Tank and personnel losses for three days of severe fighting, 18-20 July 1944, are shown in Figure 55, based on a British operations research report.* Personnel and tank loss data for these three days is shown in the figure using the average daily strength in personnel and in tanks.

The total combined arms average daily strength was 75,969. In the three days of the operation there were 4,011 casualties, or 5.28% of the average daily strength. This equates to a casualty rate of 1.76% per day during the engagement, which is a very high rate for a force of over 75,000 men.

During the operation 470 tanks or 34% of the start strength, were listed as out of action (not including 25 tanks lost by the Canadian 2d Armored Brigade on 21 July). Of these, 133 (26.9%)

*Military Operational Research Unit, Report Number 23.

Figure 55

British Casualties and Tank Losses
(Operation Goodwood, 18-20 July 1944)

Organization	Tank Losses	Average Daily Tank Loss Rate	Personnel Casualties	Average Daily Casualty Rate	Ratio of Tank Rate to Casualty Rate
7th Armored Division	63	7.29%	201	0.70%	10.41
11th Armored Division	207	24.13%	764	2.48%	9.73
Guards Armored Division	143	15.73%	287	0.98%	16.05
27th Armored Brigade	32	4.85%	59	0.72%	6.74
2d Canadian Armored Bde.	47	7.76%	66	1.07%	7.25
148th Bn., RAC	1	0.48%	6	0.30%	1.60
Total	493	13.59%	1,383	1.76%	7.72

could be repaired in 24 hours; 316 could not. Since at least 160 replacement tanks were reported received during the course of the operation, it is estimated that the average daily start strength for the three days, correcting for losses and gains, was 1,209 tanks. Using this strength figure, total tank losses were 40.78% of average strength, or 13.59% daily. The overall ratio of tank loss rate to casualty rate becomes 7.72, which is higher than the ratios for the US 6th and 4th Armored Divisions in Figure 54.

There is an immediate question as to why the ratio of tank loss to personnel casualties was so much lower for the two US armored divisions in November-December 1944, than it was for the approximately four armored divisions of the British force that took part in Operation "Goodwood." There are two reasons for this.

First, and most important, the tank to personnel ratio was nearly three times as high for the British at "Goodwood" (about 16 tanks to 1,000 personnel) as it was for the US XII Corps in Lorraine (about 6 tanks per 1,000 personnel). There are indications that in a typical combined arms force the ratio of armor loss rates to casualties increases as the proportion of tanks in the force increases.

Second, the bad weather (rain and snow) of the Lorraine Campaign lowered both personnel and armored attrition rates from what they would have been had the operation taken place in July, as did the British offensive. Loss rates for tanks tend to decline more in bad weather than casualty rates, so the ratio of tank loss rates to casualty rates would be less in bad weather.

Soviet Casualty and Tank Loss Rates

Data on casualties and tank losses of the Soviet Army in World War II is hard to obtain from open sources. Nevertheless, sufficient data has been compiled for nine campaigns involving ten tank armies to give a reasonably accurate picture of both tank losses and personnel casualties. The data is shown in Figure 56.

Soviet tank armies in World War II were composed entirely of tank and mechanized corps, and so had a large proportion of tanks. They had only about 48,000 men but had 550-750 tanks, for a ratio of about 14 tanks per 1,000 troops. The Soviet tank corps, with 11,000 men and 250 tanks, was comparable to a US armored division of 10,800 men and 263 tanks.

Although Soviet statistics on tank losses ordinarily include losses resulting from non-combat causes, the losses in Figure 56 include only those which resulted from enemy action. The campaigns were on the Eastern Front in 1943-45 and ranged in duration from two to 29 days.

Figure 56

Soviet Tank Loss and Casualty Rates
(World War II)

Campaign	Army	Number of Days	Tank Combat Losses	Average Daily Tank Loss Rate	Average Daily Casualty Rate	Ratio of Tank Loss Rate to Casualty Rate
Oboyan 1943	1T & 6G	11	761	18.75	3.09	6.07
Prokhorovka 1943	Steppe	2	380	29.23	3.65	8.01
Orel 1943	2T	9	292	8.73	1.24	7.04
Orel 1943	4T	10	520	7.07	2.11	3.35
Belgorod 1943	1T	29	577	3.54	0.86	4.12
Vistula 1944	26T	16	213	1.59	0.45	3.53
Vistula 1944	36T	19	394	2.25	0.40	4.89
E. Prussia 1944	56T	25	195	1.34	0.70	1.91
Pomerania 1945	16T	8	87	1.85	1.55	1.19

In the first three of these nine operations, the ratio of the tank loss rate to the personnel casualty rate is between 6.07 and 8.01. These ratios are typical of armor-heavy combined arms operations, in which the emphasis of one or both sides is on armored action. A combined arms force seems to reach a critical point of being armor-heavy when the ratio of tanks to 1,000 personnel exceeds a value of 6.00.

The ratio of tank loss rate to personnel casualty rate in the middle four operations in Figure 56 are between 3.35 and

4.89. Although exact strength figures for the Soviet armies are not readily available for some of these operations, in most cases the ratio of tanks to 1,000 personnel was probably less than 6.00. In any event, at the levels of aggregation shown, these were more armor-supported infantry operations than they were armored operations. This was at least partly due to the fact that German armor strength had declined greatly in later stages of the war on the Eastern Front. The result was that there were relatively few clashes of Soviet and German armor in which the loss rates were high on both sides.

The ratios of tank loss rates to personnel casualty rates in the final two campaigns listed are only 1.91 and 1.19, respectively. This is because the Russian forces were fighting a victorious action against a retreating German Army, and tank-to-tank engagements were not common.

Evaluation of World War II Tank Loss Experience

The HERO data base does not have sufficient data to permit a definitive evaluation of World War II tank loss experience. This is due in part to the difference between tank operations on the Western Front and those on the Eastern Front. There was only one large (corps level or higher) armor or armor-heavy operation on the Western Front comparable to the many such operations that were fought on the Eastern Front. Without further research, HERO could not compile data for Soviet tank corps operations comparable to the relatively abundant data for US armored divisions, some of which HERO has compiled.

Nevertheless, there is sufficient data compiled from both Eastern Front and Western Front operations to demonstrate that armored conflict experience followed very similar patterns on both fronts. (This similarity is a basis for some confidence in the relatively unreliable Eastern Front data.) Figure 57 shows selected data on six Eastern Front operations and three Western Front operations involving armored conflict.

Figure 57

Selected Data on World War II Tank Operations

Eastern Front	Average Personnel Strength	Average Tank Strength	Tanks per 1,000 Troops	Ratio of Tank Loss Rate to Casualty Rate
Soviets				
Kursk-Oboyan	89,000	361	4	6.87
Kursk-Prokhorovka	78,000	650	8	8.01
Belgorod A	981,000	2,296	2	4.87
Belgorod B	70,000	562	8	4.12
Belgorod C	70,000	500	7	4.84
Korsun	255,000	431	2	3.20
Germans				
Kursk-Oboyan	58,000	476	8	6.26
Kursk-Prokhorovka	82,000	505	6	6.39
Belgorod A	280,000	600	2	3.99
Belgorod B	24,000	150	6	1.49
Belgorod C	15,000	130	9	3.99
Korsun	85,000	229	3	1.24
Western Front				
Allies				
Goodwood	75,000	1,209	16	7.72
Arracourt	4,900	122	25	8.39
Lorraine-Saar	32,000	272	9	3.64
Germans				
Goodwood	58,000	528	9	4.36
Arracourt	7,500	126	17	6.62
Lorraine-Saar	17,000	120	7	4.32

Two of the Eastern Front operations are part of the Kursk battle (or campaign), and three are from the Belgorod campaign which immediately followed Kursk. The first two operations in the Oboyan and Prokhorovka sectors of the Kursk battle were armor-heavy, combined arms operations in which the proportion of tanks on each side exceeded 6 per 1,000 personnel, and in which the emphasis -- at German initiative -- was on armored action.

The Belgorod campaign, on the other hand, was essentially an armor-supported infantry offensive, even on the front of the Soviet First Tank Army (Belgorod B), where the proportion of armor to 1,000 personnel also exceeded the apparently critical figure of 6.

The three tank operations on the Western Front in 1944 are representative of three distinct types. The first of these, the British Operation "Goodwood," was the only major Western Front operation between large armor-heavy forces comparable to those fought on the Eastern Front. The second, Arracourt, while the results were somewhat more one-sided than most others, was typical of clashes between small armored forces on all fronts. The third, an eight-day segment of the Lorraine-Sarre Campaign, was typical of armor-supported infantry operations.

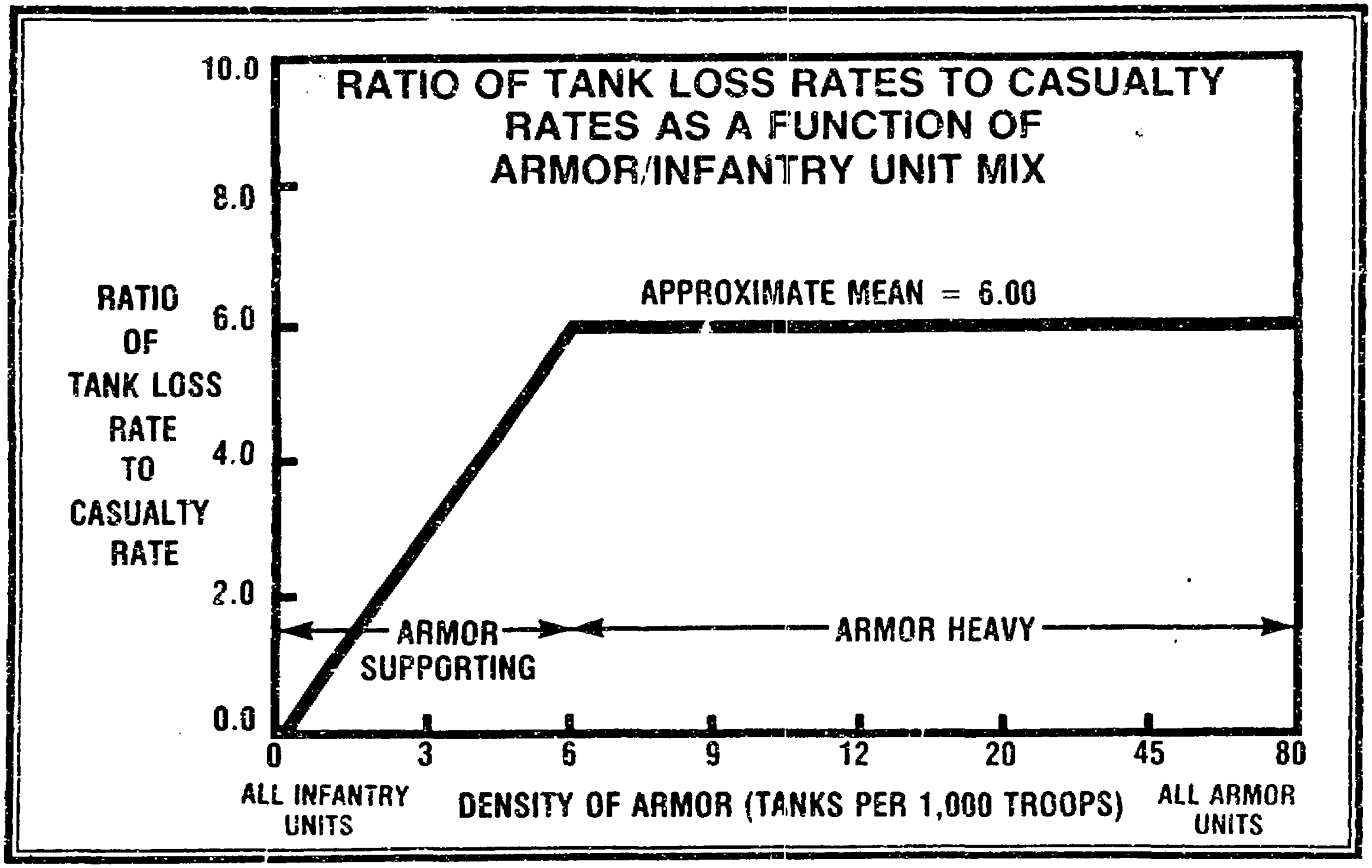
A comparison of US and Soviet tank losses in World War II shows a significant difference in scale. The US First Army reported only 1,878 tanks lost for ten months of operations in Northwest Europe, and the US Third Army reported a loss of 102% of its average tank strength in a period of nine months. Yet, the Soviet First Guards Tank Army lost 1,040 tanks, or 185% of its 562 tank starting strength, in the 29 days of the 1943

Belgorod operation alone. However, the remainder of the Soviet Voronezh Army Group in that operation -- some 900,000 men supported by about 1,700 additional tanks -- lost only about 900 tanks in those same 29 days. While this was a high loss rate in comparision with the experience of the First US Army, it was a rate only about one-third that of the Soviet First Tank Army in that operation.

Nevertheless, taking into consideration the difference in overall scale, Figure 57 demonstrates that in comparable operations, the attrition experience of US and British armored forces on the Western Front was generally similar in nature and pattern to that of Soviet armored forces on the Eastern Front.

Moreover, the data of Figure 57 suggests that there is a distinct pattern with respect to the ratio of the tank loss rate to the casualty rate. This pattern is shown in Figure 58.

Figure 58



RATIO OF TANK LOSS RATES TO CASUALTY RATES AS A FUNCTION OF ARMOR/INFANTRY UNIT MIX
RATIO OF TANK LOSS RATE TO CASUALTY RATE
10.0
8.0
6.0
4.0
2.0
0.0
APPROXIMATE MEAN = 6.00
ARMOR SUPPORTING
ARMOR HEAVY
0
3
6
9
12
20
45
80
ALL INFANTRY UNITS
DENSITY OF ARMOR (TANKS PER 1,000 TROOPS)
ALL ARMOR UNITS

The ratio of the tank loss rate to the casualty rate appears to be a function of the density or proportion of tanks in the force. A force can be considered armor-heavy when the proportion of tanks exceeds 6 per 1,000 troops. When two armor-heavy forces engage in battle, whether for a long or short period, the ratio of the tank loss rates to the casualty rates will be in the range of 5.00 to 8.00, with an average value of about 6.00. There are, of course, exceptions, as there always are in combat data, where each event is <u>sui generis</u>, but the pattern is clear. Furthermore, this ratio of tank loss rates to casualty rates appears to remain relatively constant as the proportion of tanks increases above 6 per 1,000 troops. On the other hand, that ratio decreases, apparently in more-or-less linear fashion, when the proportion of tanks declines below 6 per 1,000 troops. It appears further that the range of the ratio for an armor-heavy force is between 5 and 7 for a winner and between 6 and 8 for a loser. This relationship provides a valuable tool for modelling and predicting tank losses relative topersonnel casualties.

Casualty and Tank Loss Rates in the 1973 Arab-Israeli War

Since neither side in the 1973 Arab-Israeli War has published statistics on the combat experience, it has been necessary to search many sources and interview participants on both sides in order to estimate strengths and losses with any degree of confidence. The data in Figure 59 has been compiled after considerable research, and the overall figures are considered to be reasonably accurate.

Figure 59

Selected Data on Tank Operations: 1973 Arab-Israeli War

	Average Personnel Strength	Average Tank Strength	Tanks per 1,000 Troops	Ratio of Tank Loss Rate to Casualty Rate
Sinai Front				
Israelis	17,000	306	18	5.42
Egyptians	34,000	316	9	7.21
Golan Front				
Israelis	12,500	183	15	5.26
Syrians	17,000	248	15	7.71

The HERO data on tank engagements in the 1973 War is organized by combat engagements, 16 on the Sinai Front, covering 24 combat days, and 14 on the Golan Front, covering 20 days. Both armored and infantry units were involved in these engagements, most of which were fought by a division-sized force on one side, against a force the size of a brigade or larger on the other. Data for individual engagements (not shown in Figure 59) has been estimated by allocation from the statistics for the entire campaign, on the basis of considerable detailed information about each engagement.

The ratios of tank loss rates to personnel casualty rates in the 1973 War are quite consistent with those of US, British, Soviet, and Germans units shown in Figure 57 for World War II. The winners had ratios of about 5, and the losers had ratios of about 7. This is further evidence of the general relationship of tank loss rates and casualty rates shown in Figure 58.

Artillery Loss Rates in World War II

Loss rates of artillery weapons generally are low in comparison to personnel and tank loss rates. Figure 60 shows the experience of the US Army and German Army in 1943 and 1944 during World War II. Another indication of low artillery loss rates is shown in Figure 61, which summarizes the experience of eight US Army divisions in three theaters in World War II. The gun loss rates are so low they are expressed as monthly rather than daily rates.

Figure 60

Selected World War II Artillery Loss Data

	Average Daily Personnel Casualty Rate	Average Artillery Pieces Committed	Artillery Losses	Daily Artillery Loss Rate	Ratio of Artillery Loss Rate to Casualty Rate
US ARMY					
US First Army					
(8/44-2/45)	0.20	677	58	0.037	0.185
(12/44)	0.56	583	37	0.576	1.030
US Third Army					
(10/44-12/44)	0.25	664	25	0.041	0.164
US Fifth Army					
(9/43-9/44)	0.08	452	62	0.038	0.475
(1/44-3/44)	0.16	346	23	0.098	0.613
(5/44-6/44)	0.25	410	11	0.049	0.175
US Tenth Army					
(4/44-6/44)	0.28	243	11	0.049	0.175
GERMAN ARMY					
Wehrmacht					
(Aug 1944)	0.42	7,086	1,217	0.554	1.320
(Sept 1944)	0.30	6,976	369	0.176	0.587
(Avg 1944)	0.14	6,820	299	0.146	1.081
Fourth Army					
(Nov 1943)	0.16	423	16	0.126	0.788

In World War II the US Army lost relatively few artillery pieces to enemy action, and a statistically insignificant number of artillery crew members were killed or wounded as a result of enemy action which damaged an artillery piece. Several divisons reported that they lost neither artillery pieces nor gun crew personnel while serving the pieces for the entire war. Consequently, statistical correlations between crew and artillery piece losses are not possible. A large proportion of artillery personnel losses are among forward observer and liaison personnel with maneuver units.

Figure 61

US Gun Losses in World War II

Theater	Number of Battalions	Combat Days	Gun Losses	Average Monthly Loss Rate %	% Cause of Loss Enemy Artillery	Air Attack	Other
<u>Towed Weapons</u>							
North Africa	7	273	11	10.1%	54	36	10
Italy	16	2,097	26	3.1%	65	27	8
Europe	8	355	4	2.8%	67	23	10
<u>Self-Propelled Weapons</u>							
North Africa	3	165	7	7.1%	43	43	14
Italy	3	553	6	1.8%	50	17	33
Europe	11	461	4	1.4%	55	18	27

The experience of individual US divisions varied considerably, ranging from those which had no artillery losses during the entire war to those which suffered considerable losses in single battles such as the German Ardennes offensive in December 1944. To derive approximate divisional combat intensity rates from these army statistics, the following two considerations must be recognized: 1) the strength-size factor;

and 2) varying levels of commitment of combat and combat support elements, depending upon the intensity of combat.

The strength-size factor is not as important for artillery loss rates as it is for casualty rates. In general, the field army casualty rates are about one-fourth of those of its component divisions while engaged in intensive combat. This is because fewer of the personnel in a field army are exposed to hostile fire than in a division. On the other hand, it can be assumed that most available artillery, even of large organizations, will be committed to combat, so that artillery loss rates of field armies will be only slightly lower than those of constituent divisions. The mean artillery loss rate for the World War II experience shown in Figure 60 is 0.172% per day.

It can be seen from in Figure 60 that under conditions of "average" combat, and under "average" environmental conditions, artillery loss rates were substantially lower than field army casualty rates. The ratio of artillery loss rates to field army casualty rates ranges from 0.164 to 1.320, with a mean of 0.599.

Where one side had overwhelming air superiority in terrain and climate situations where air could be effective against artillery, the rate for the side with air superiority was reduced by about one-half to one-third. This is shown by the experience of the US First Army from 8/44 to 2/45, of the US Third Army, and of the US Tenth Army from 4/44 to 6/44.

In intensive combat artillery loss rates tended to increase more than personnel loss rates. This is shown by the experience of the US First Army in 12/44, of the US Fifth Army from 1/44 to

3/44, and of the German Fourth Army.

In periods of warm weather and long days, personnel casualties rose at a greater rate than did artillery losses. This is shown by the experience of the US Fifth Army from 5/44 to 6/44 and the Wehrmacht during September 1944.

Causes of Artillery Losses

Figure 62 shows personnel casualties by cause for US field artillery units in North Africa, Italy, and Europe. Hostile artillery fire accounted for one-third to one-half of artillery casualties. Air attack was the second largest cause of artillery casualties. The high losses due to tank attack in North Africa reflect the far greater fluidity of the combat environment in North Africa, as well as the much higher degree of German initiative in that theater. Most of the casualties listed as "unknown occurred at such a distance from the front lines that artillery and air attack must be assumed to be the most likely cause. Data for self-propelled artillery units is generally consistent with the data for the towed artillery units.

Figure 62

Artillery Personnel Casualties by Cause

Theater	Type of Artillery	Combat Days	% by Cause Artillery	Air Atck	Other*	Unknown
North Africa						
	Towed	273	37	13	43**	7
	Self-Propelled	165	6	23	6	66***
Italy						
	Towed	176	44	20	11	25
	Self-Propelled	553	50	9	8	33
Europe						
	Towed	355	14	30	27****	29
	Self-Propelled	461	40	9	8	43

*Includes mortars, tanks, small arms, machine guns, and mines.
**Includes 23% from tanks.
***Includes 140 personnel missing in action after being overrun.
****Includes 20% from mortars.

Gun Crew Casualties and Gun Losses

The data in Figure 63 is based on a data sample of 63 gun losses, which excludes catastrophic gun losses.

Figure 63

Gun Losses and Crew Casualties
(11 US Army Divisions, 1942-1944)

Type of Artillery	Total Gun Losses	Artillery Crew Casualties	Crew Casualties Per Gun Loss
Light & Medium Towed	45	184	4.09
Self-Propelled	18	32	1.78

The average number of crew personnel harmed when towed pieces were destroyed or damaged by enemy attack was over double the average for the self-propelled battalions. For towed guns the average number of crew casualties per gun loss was about four, although 13 guns (29% of the sample) were destroyed or damaged by hostile attack without any resulting casualties. For self-propelled guns there was an average of less than two casualties for each gun loss, including five gun losses in which no casualties occurred.

The lower average of the self-propelled battalions may be attributed in part to the protection afforded by the armor plate of the self-propelled pieces. It is possible also that some of the self-propelled gun losses resulted from damage to the vehicle itself rather than to the gun compartment where the crew rides. Despite the lower casualty rates related to gun losses in self-propelled artillery units, the overall personnel casualty rates in self-propelled units were greater than the rates in towed units. One reason for this is that self-propelled units were almost all light artillery in the direct support role for armored units and deployed closer to the front lines than was usual for units with towed weapons. Another reason is that a high proportion of the engagements in which self-propelled units were in action were in mobile operations in which battalion personnel not protected by the armor of the weapons were not so well dug-in as was normal for personnel operating towed weapons.

Catastrophic Gun Losses

Whenever artillery loss rates exceed 0.15% per day, it may be assumed that these are catastrophic losses due to close combat and overrun. The French lost all, and the British most, of their guns as a result of the 1940 German offensive. Probably the worst case in recorded history occurred during Operation "BARBAROSSA" when the Russian Army lost 16,179 guns and mortars.

US catastrophic gun losses in World War II are shown in Figure 64. Several engagements in Tunisia resulted in catastrophic losses by American artillery units. Some US units were surprised by the German Ardennes offensive of 1944 and experienced a 100% catastrophic gun loss.

Catastrophic gun losses did not occur in the armies of the Western Allies from the summer of 1943 until December 1944, because Allied forces in Italy, France, and Germany were almost constantly on the offensive. Local small-scale German counterattacks never penetrated into the artillery position areas behind the front lines. For the Axis armies, however, catastrophic gun losses became more and more common beginning in May 1944.

Until the German Ardennes counteroffensive in December 1944 most of the US artillery units that were involved in close combat in Europe were the self-propelled battalions of armored divisions. These came under attack in fluid situations in which the front was ill-defined. The majority of such actions occurred during the Normandy breakout and the subsequent pursuit across France to the German border.

Figure 64

US Catastrophic Gun Losses in World War II

Theater	Date	Gun Loss	% Gun Loss	Cause
North Africa				
27th Armored FA Bn	6 Dec 42	5	28	Tank overrun
91st Armored FA Bn	14 Feb 43	10	56	Tank overrun
5th FA Bn	23 Mar 43	4	33	Tank/Inf overrun
Ardennes				
589 FA Bn	16-24 Dec 44	12	100	Tank/Inf overrun
590 FA Bn	21 Dec 44	12	100	Surrender (?)
924 FA Bn	17-18 Dec 44	3	25	Abandoned in retreat
371 FA Bn	17-18 Dec 44	7	58	Abandoned in retreat

Catastrophic gun losses are directly correlated with the posture and relative success of armies. Successful armies pursuing the offensive will not suffer major catastrophic gun losses, although an occasional isolated lower echelon catastrophic gun loss may occur.

Artillery Loss Rates in the 1973 Arab-Israeli War

Based upon the overall statistical comparison, the artillery loss rates of both Israelis and Arabs, as shown in Figure 65, were about five times higher than the average rates of artillery losses in World War II. Both Arab and Israeli artillery loss rates were also two to three times higher than World War II artillery loss rates for relatively short periods of intensive combat.

The principal reasons for the higher Israeli losses are as follows:

1. Higher vulnerability of Israeli self-propelled weapons in comparison to towed artillery by a factor of about 3.0.

2. Greater vulnerability of all artillery weapons in a desert environment by a factor of about 1.5.

3. Israeli deployment of artillery, particularly long-range artillery, much closer to the front than standard doctrine in World War II, increasing artillery losses by a factor of about 1.2.

Figure 65

Relation of Artillery Loss Rates to Casualty Rates:

1973 Arab-Israeli War

Engagement Analysis	Average Daily Personnel Casualty Rate	Average Artillery Strength	Artillery Losses	Average Daily Artillery Loss Rate	Ratio of Artillery Loss Rate to Casualty Rate
Sinai Front					
Israelis	1.46	144	30	0.87	0.596
Egyptians	2.05	484	140	1.21	0.590
Golan Front					
Israelis	1.34	72	15	0.91	0.679
Syrians	2.59	362	75	0.91	0.351

The principal reasons for the higher Arab losses are as follows:

1. Less flexibility and mobility when under fire, increasing losses by a factor of about 2.0.

2. Greater vulnerability of all artillery weapons in a desert environment by factor of about 1.5.

3. Substantial Israeli air superiority, particularly

to·ard the end of the war, increasing artillery losses by a factor estimated to be 1.4.

This analysis leads to the following two conclusions:

1. Israeli artillery loss rates would be expected to be about five times greater than US and German loss rates in World War II, from the product of the three factors (3.0 x 1.5 x 1.2 = 5.4).

2. Arab artillery loss rates would be expected to be about four times greater than US and German loss rates in World War II, from the product of the three factors (2.0 x 1.5 x1.4= 4.2).

These findings are consistent with the data in Figure 65.

Helicopter Loss Rates in Vietnam

Helicopters have been used extensively only in the Korean War, the 1973 Arab-Israeli War, and the Vietnam War. Significant data is available for only one of these -- Vietnam, 1965-1970. However, even the available data on Vietnam is in very general, aggregated form. Furthermore, it must be recognized that the experience of the United States with helicopters in the Vietnam War was in a relatively benign air environment. The United States enjoyed air supremacy, and the enemy was limited in the quantity and quality of ground air defense weapons.

Despite these limitations regarding the data, analysis of US helicopter attrition experience in Vietnam does provide some useful insights. Figure 66 shows the relationship of annual helicopter loss rates with annual personnel casualty rates. The mean ratio of helicopter loss rates to casualty rates is 4.0. If the very high ratio for 1970 is excluded, the mean ratio is 3.4. Helicopter loss rates increased substantially for the Army after 1968, when ground force strength was beginning to decline. This suggests that operational commanders relied increasingly on helicopters to provide the mobility and firepower that would otherwise have been reduced due to the decline in ground personnel strength.

Figure 66

Helicopter Loss Rates in Vietnam

Year	Annual Theater Casualty Rate - %	Annual Theater Helicopter Loss Rates - %			Ratio of Total Helicopter Loss Rates to Casualty Rates
		USA	USMC	TOTAL	
1965	1.52	5.5	5.2	5.4	3.6
1966	3.52	11.2	28.4	13.3	3.8
1967	6.11	14.7	29.4	16.2	2.7
1968	8.58	27.0	32.8	28.0	3.3
1969	7.84	26.8	32.5	27.5	3.5
1970	4.61	33.0	36.0	33.3	7.2

While the data for helicopter strengths and losses in Vietnam does not distinguish between non-attack and attack helicopters, the data does differentiate between US Army and US Marine Corps experience. Since the Marine Corps had a higher proportion of attack helicopters than the Army in Vietnam, this may be why there is a difference between the Army helicopter loss rates and Marine Corps loss rates. If it is assumed that combat loss rates for the two services were roughly comparable, then the higher loss rate for the Marine helicopters would suggest that the loss rates for attack helicopters alone were substantially higher than the overall rates shown.

The data in Figure 66 demonstrates the substantial vulnerability of the helicopter, even under the relatively "benign" conditions already noted. This could raise questions as to the kinds of helicopter loss rates that might be suffered in a less benign environment, such as Central Europe. On the other hand, World War II experience with combat aircraft losses suggests that when the aircraft loss rate exceeds a certain threshhold, the level of air activity drops. This is not inconsistent with the fact that neither Arabs nor Israelis have made extensive combat use of helicopters -- as opposed to administrative use -- in their conflicts, which may be due to the highly lethal air defense environment in the Arab-Israeli wars.

Other Materiel Losses

The data presented above on tank and artillery loss rates suggests that there is a close correlation between personnel casualty rates and the loss rates for weapons and other materiel items. A previous HERO study also suggests that there is an increase in the loss rates of some materiel items during prolonged campaigns, particularly campaign· which there is considerable movement.* The relationship of this phenomenon to non-battle wearout and breakdown rates is not clear and requires further research and analysis.

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*HERO Report 14, "Wartime Replacement Requirements," 1966.

Figure 67 presents a summary of loss rates for selected weapons and equipment items, including tanks and artillery, compared to a standard personnel casualty rate of 1% per day. These factors are based on analyses similar to those presented herein. Additional work is needed to treat helicopter losses in a similar manner.

Figure 67

Daily Loss Rates of Selected Materiel Items
Normalized to a Personnel Casualty Rate of 1%

	Daily Loss Rate
Tanks	6.00**
Artillery	0.25
Trucks p	0.50
Small Arms	0.79
Mortars	1.00
Machine Guns	1.25
Radios	1.00

**Use this factor if the proporation of tanks per 1,000 troops is 6 or greater. If the proportion is less than 6, the tank loss rate factor will be the same as the number of tanks per 1,000 troops.

The implications of the relationships between personnel casualty rates and materiel loss rates are profound. The relationships provide the military analyst a method of estimating materiel losses when personnel casualties are known. Or, the personnel casualties can be estimated if materiel losses are known. If neither casualties nor materiel losses are known, the relationship will still allow estimates of materiel losses to be made based on estimates of personnel losses based on the interaction of the circumstances of combat as explained in the previous chapters. While historical analysis of materiel attrition is not as advanced as the historical analysis of personnel attrition, the identification of rough relationships between personnel casualty rates and materiel loss rates for different types of materiel provide a solid foundation for additional progress in this area.

Chapter 7

ATTRITION VERITIES

Based upon observed patterns of attrition in modern combat a set of hypotheses with respect to personnel and materiel attrition has been formulated. These are the "Attrition Verities." The first two verities do not deal with attrition directly but have great significance for understanding attrition. The 28 attrition verities which have been formulated by HERO on the basis of historical observations and analyses are as follows:

1. In the average modern battle, the attacker's numerical strength is about double the defender's. This is because the attacker has the initiative and can initiate combat at a time and place of his choosing and in the manner of his choosing. The attacker can mass his forces at critical points on the battlefield to gain the advantage in strength which he believes necessary to assure the success of the attack.

A battle usually does not take place unless each side believes it has some chance for success. Otherwise, the attacker would avoid taking the initiative. The defender, if he could not avoid battle by withdrawal, would make every possible effort to reinforce the prospective battle area sufficiently to have a chance for successful defense. One circumstance in which a battle occurs without the tacit agreement or acceptance of the defender, is when the attacker achieves surprise. Alternatively, surprise by a defender (for instance, by ambush) may result in a battle taking place before the prospective attacker is ready.

Most military men are aware of the rule of thumb that an attacker can count on success if he has a three-to-one numerical superiority, while a defender can expect success if his inferiority is not less than one-to-two. But the side achieving surprise can count on the effects of surprise multiplying its force strength by a factor ranging between 1.5 and 2.5 (or even more in some cases). Thus, an attacker expecting to achieve surprise would be willing to attack with less than a three-to-one superiority.

Another factor which can influence an attacker to seek battle with less than a three-to-one superiority is confidence in the superior quality of his troops. This accounts for many instances in which the Germans attacked in World War II with less than the desirable numerical superiority, and for the similar instances of Israeli attacks in the Arab-Israeli wars without great numerical superiority.

2. In the average modern battle, the attacker is more often successful than the defender. In 595 battles between 1600 and 1973 the attacker was successful in 361 battles, or 61%. This is true also of World War II and the Arab-Israeli wars in which the attacker was successful in about 75% of the engagements studied. It makes historical sense that most wars are won by the side that has been on the offensive longer and more successfully.

3. Attrition rates of winners are lower than those of losers. The attrition rates (not absolute numbers) of successful forces are almost invariably lower than rates of their unsuccessful opponents. This is generally true regardless of

which is attacker and which is defender.

4. Small force casualty rates are higher than those of large forces. Writing nearly 100 years ago, American military historian Theodore Ayrault Dodge noted that this phenomenon was as evident in the battles of antiquity as in the wars of the 19th Century. It is also true today that under comparable or equivalent circumstances smaller forces always have higher casualty rates than larger forces. This is due in part to the fact that larger forces usually have a smaller proportion of their personnel strength exposed directly to hostile fire than do smaller forces and in part due to the effect of "friction" upon larger forces.

5. More effective forces inflict casualties at a higher rate than less effective opponents. Relative combat effectiveness is influenced by the interaction of many variables, such as leadership, morale, training, and experience. One of the major results of higher relative combat effectiveness is the ability to inflict casualties on the less effective opponent at a higher rate than the opponent can inflict casualties. This relationship seems to be proportional to the ratio of the combat effectiveness values of the two sides.

6. There is no direct relationship between force ratios and attrition rates. Attrition rates depend on many factors, such as weather, terrain, tactical posture, and relative combat effectiveness. Accordingly, the influence of personnel strength ratios or force strength ratios on attrition rates is reduced to a point where no clear relationship exists. Combat power ratios which take into account the circumstances of combat do influence

attrition rates as one of several interacting factors.

7. In the average modern battle, the numerical losses of attacker and defender are similar. This seems to be true when the combat effectiveness of the opponents does not differ markedly and the battle outcome is not an overwhelming catastrophe for the defender. For many reasons, comparisons of numbers are less useful than comparison of rates.

8. Loss rates for defenders vary inversely with strength of fortifications. The outcome of a battle depends on many factors, and the casualties and casualty rates for both sides depend on more than the strength of the defensive fortifications. However, to the extent that history permits such comparisons, it is evident that if other conditions remain unchanged, defenders in prepared positions will suffer fewer casualties than if they were in a hasty defense, and they will inflict more casualties on the attackers. The converse is true also. Loss rates of attackers vary directly with the strength of the defender's fortifications.

9. Loss rates of a surprising force are lower than those of a surprised force. This is because the organized and determined forces of the surpriser, fully prepared for battle and given greater confidence by the knowledge that the opponent is caught unawares, perform more effectively at the moment of surprise. The forces being surprised, on the other hand, are disorganized, unprepared, and possibly demoralized, and are less effective until they recover from being surprised.

10. In the average modern battle, attacker loss rates are somewhat lower than defender loss rates. This is because winners

have lower casualty rates than losers, and attackers win more often than defenders. This is also because attackers achieve surprise much more often than defenders, since attackers have the initiative. Also, the attacker is usually more numerous than the defender, but the numerical losses of both sides are usually similar.

11. <u>In bad weather, casualty rates for both sides decline markedly</u>. This is because soldiers do not use their weapons as effectively in inclement weather as they do in good weather. More time is spent surviving or remaining comfortable than in bringing fire to bear on the opponent.

12. <u>In difficult terrain, casualty rates for both sides decline markedly</u>. This, too, is a reflection of the effectiveness of employing weapons. In rugged terrain more effort has to be used to move, and less effort is available for firing weapons. Difficult terrain also slows up resupply of ammunition, which causes lower firing rates for both sides.

13. <u>The casualty-inflicting capability of a force declines after each successive day in combat</u>. The reason for this phenomenon is not clear, although fatigue is unquestionably a factor. The reduction in capability occurs steadily while the unit is in combat, but capability is recovered fairly rapidly after short periods of rest out of combat. The degradation of casualty-inflicting capability is one way in which the effect of casualties incurred on unit effectiveness can be determined and measured. More research needs to be done on this phenomenon.

14. <u>Casualty rates are lower at night than in daytime</u>. This is another example of casualty rates being related to

opportunities to employ weapons effectively. There is simply less capability to acquire targets and bring fire to bear on them at night than in daylight.

15. Casualty rates are higher in summer than in winter. This applies primarily to temperate climates where the distinction between summer and winter is marked by substantial differences in the hours of daylight. The increased daylight available in summer for effective employment of weapons seems to be only slightly offset by the inhibiting effects of more luxuriant foliage.

16. The faster the front line moves, the lower the casualty rates for both sides. The reason for this phenomenon, which is validated by historical experience in combat in World Wars I and II, is that troops advancing rapidly have less time to use their weapons than troops advancing slowly. When the rate of advance is rapid, more of the soldier's time is spent on the movement itself, and less time is available to bring fire to bear on targets. At the same time, it is more difficult to acquire targets during rapid movement, so the defenders are hit less often.

17. Casualty rates decline during river crossings. This phenomenon, which needs further study, is apparently due to the fact that attackers are very largely occupied with matters other than using their weapons, and the number of exposed targets for defenders to fire at is generally smaller than usual, except at the actual crossing site.

18. An "all-out" effort by one side raises loss rates for both sides. This is true whether it be the attacker making an attack a outrance, or a defender holding a position "at all costs." This verity is simply a result of the fact that a commander willing to take higher losses to accomplish his mission will, in fact, incur those higher losses, but will force his opponent also to fight more intensively and be more exposed.

19. A force with greater overall combat power inflicts casualties at a greater rate than the opponent. Combat power includes consideration of the environmental, operational, and human factors which comprise the circumstances of a particular battle or engagement. A numerically inferior force in well-prepared defenses with highly mobile reserves and good morale and leadership could have greater combat power than a numerically stronger attacker. This can be true even if the attacker has a higher combat effectiveness. It is the aggregate of the various factors which determines the ability to inflict casualties on the opponent.

20. The breakout of personnel casualties in 20th Century warfare is consistent. About 20% of battle casualties are killed immediately. This corresponds to a wounded-to-killed ratio of 4. About 65% of battle casualties survive their wounds, even with minimal care. The proportion of seriously wounded who survive has increased over the past century from less than 5% to more than 10% due to improvements in medical evacuation and treatment.

21. Materiel loss rates are related to personnel casualty rates. People are hit in most cases when tanks, vehicles, and artillery weapons are hit. Thus, personnel casualties are caused

by the same impacts which destroy or damage materiel. This means that there are relationships between personnel casualties and materiel losses which can be used to estimate the latter, given the former. These relationships vary from item to item, and they depend on battlefield density and distribution of the equipment and its relative vulnerability to damage from hostile fire.

22. Tank loss rates are five to seven times higher than personnel casualty rates. This applies to combined arms engagements in which armored forces make up a substantial proportion of the fighting strength on one or both sides.

23. Attacker tank loss rates are generally higher than defender tank loss rates. This is in relation to personnel casualty rates on the opposing sides. If the attacker's tank loss rate is about seven times that of the attacking personnel casualty rate, the defender's tank loss rate will probably be closer to five times (or even less) the defender's casualty rate.

24. Artillery materiel loss rates are generally about one-tenth personnel casualty rates. This is an observed phenomenon which applies to artillery pieces hit by enemy fire. It does not include catastrophic losses of artillery pieces due to overrun or surrender.

25. Self-propelled artillery loss rates are about three times greater than for towed guns. This is due to a combination of factors: larger exposed target; presence of fuel and ammunition in the self-propelled guns; and vulnerability of engines to damage.

26. Average World War II division engagement casualty rates were one to three percent a day. Successful divisions in Western Europe lost about one to two percent casualties a day in intensive combat; losing divisions lost about two to three percent a day.

27. Attrition rates in the 1973 October War were comparable to World War II. In spite of the increased lethality of weapons and the greater sophistication of military technology, personnel casualty rates and tank loss rates for engagements in the 1973 war seem to have been approximately the same as those for both personnel and tanks in intensive battles of World War II in Western Europe; they were slightly less than comparable World War II loss rates on the Eastern Front.

28. Casualty rates in minor hostilities after 1945 are about half those experienced in World War II. This may be due primarily to the absence of sustained artillery fire in many of these kinds of combat engagements.

SELECT, ANNOTATED BIBLIOGRAPHY

This bibliography provides an annotated listing of significant secondary works containing attrition data or analysis of casualty and materiel loss data of historical wars, campaigns, and battles. It lists and describes important works and is not intended to be all-encompassing. Major criteria for inclusion are importance and usefulness, either as data source or as methodological contribution, or both.

The organization of the bibliography is in two parts. Part One is a listing of general sources, that is, books and other literature that provide data and analysis of military attrition statistics of two or more wars or historical periods. Part Two is a listing of specific sources or works reporting military attrition experience in specific modern wars or historical periods.

Part One: General Sources

Armed Forces Information School. The Army Almanac. Washington, D.C.: U.S. Government Printing Office, 1950.

This is an official fact book and reference source of data concerning the US Army and, to a limited extent, other services of the US armed forces, that contains detailed statistical information on US Army personnel strengths and casualties in 20th century wars through World War II. A useful summary table gives US Army troops and casualties in principal wars from the American Revolution to World War II, inclusive. The volume consulted was published in 1950; other volumes appear to have been published on a regular basis up to 1959, at least.

Berndt, Otto. Die Zahl im Kriege: Statistische Daten aus der neuern Kriegsgeschichte in graphischer Darstellung. Vienna: Freytag & Berndt, 1897.

This is a data base of strength, casualty, and duration data covering major European wars, campaigns, and battles from 1740 to 1895. Much data is presented, mostly in graphical form, using tables and diagrams accompanied by figures. The statistical coverage of wars and campaigns is limited. However, strength, casualty, and duration data is given for approximately 100 land battles, large cavalry engagements, naval engagements, and sieges. The data base is supplemented by some useful analyses of strength and casualty data.

This is an impressive effort, though much smaller and less useful in many respects than the data base compiled by Bodart (q.v.) a few years afterward.

Bodart, Gaston. Militaer-historisches Kriegs-Lexikon. Vienna and Leipzig: C.W. Stern, 1908.

This is a large data base and statistical analysis of land battles and sieges and naval battles during the period 1618-1905. The coverage is extensive, comprehending some 1,000 examples, but the primary emphasis is on the battles and sieges of the great powers in the period indicated. The data reporting varies in detail, reflecting the strengths and weaknesses of the source material, which includes primary and secondary references. The author's bibliography of sources, organized chronologically by war or conflict, is given in pages 16-31 of the work. The entries for individual land battles and sieges and naval battles generally report the following data:

Name
Date(s)
Geographical location
National or other identification of opposing sides
Commanders
Strengths
Personnel casualties
Materiel losses

Most entries include a brief statement identifying the victor, if applicable, and, for battles only, a number on a scale of 1 to 6 indicating the relative categorical rank of the battle based on the total of personnel casualties incurred by both sides.

For land battles and sieges the strength data for each side gives:

Number of men
Number of cavalrymen
Number of artillery guns

The loss data for each side gives:

Total personnel casualties
"Bloody losses" (this is the author's term for the total of killed in action and wounded in action)
Number captured and missing
Number of artillery guns lost
Number of flags, standards, and kettledrums lost

For naval battles the strength data for each side includes:

Number of men
Number of ships' guns
Number of line of battle or capital ships
Number of frigates
Number of smaller ships

The loss data for each side includes:

Number of men (total and killed or captured)
Number of ships' guns
Number of ships (by category)

Strength and loss data for sieges and storms of fortified places is reported like that for land battles, but usually in summary form. All data is reported to the extent it was discoverable by the author or applicable to a particular battle or siege. A unique attribute of the data reported for each battle or siege is the listing by name and grade of all general officers killed or mortally wounded during the course of the event.

The final section of the work is devoted to an extensive analysis of conflict and the trends in warfare during 1618-1905, based in large part on the data base of engagements. The Kriegs-Lexicon remains to this day the greatest, most ambitious data base of engagements and related data, a monument to the industry of its compiler.

Eggenberger, David. A Dictionary of Battles. New York: Thomas Y. Crowell, 1967.

The author's preface states that: "This book attempts to provide the essential details of all the major battles in recorded history." However, this ambitious objective is not met, not even approached. What is provided, for 1,560 engagements and battles from Megiddo (1479 B.C.) to Vietnam in the mid-1960s, are brief narrative summaries, accompanied generally by data on personnel strengths and casualties of the opposing sides. But many entries either do not provide strength and casualty data or provide incomplete data. The main problem with the work is that its coverage is uneven: it is fairly complete and accurate for European and American history (despite some major errors and omissions) but poor for the rest of the world before the 20th Century.

Historical Evaluation Research Organization. Analysis of Factors That Have Influenced Outcomes of Battles and Wars: A Data Base of Battles and Engagements. Report No. 95. 6 vols. Dunn Loring, Va.: HERO, 1984.

This report presents data on 601 major battles of modern history from 1600 to 1973 in a combination of matrices and narratives. The matrices comprise seven tables, which show all of the significant statistical data available on the battles, including attrition data, and show how major factors of combat influenced the outcomes of the battles. In addition, the background, course, and outcome of each battle is concisely described in a narrative, which summarizes principal sources consulted for research.

The data base of battles developed for this study is called the HERO Land Warfare Data Base; it is routinely corrected, refined, updated, and enhanced, as new or better data becomes available. HERO has just completed a major effort to refine and enhance selected aspects of the data base under contract to the US Army's Concepts Analysis Agency.

________. Artillery Survivability in Modern War. Report No. 55. Dunn Loring, Va.: HERO, 1976.

For a very limited exploratory study a historical data base of artillery gun losses in modern war was compiled from primary sources, including unit operational records. The emphasis is on gun loss patterns in World War II (US and German experience), but data was also developed for Korea and the October 1973 Arab-Israeli War, primarily for comparative purposes. The analysis permitted development of some tentative planning factors for artillery gun loss rates in differing intensities of combat.

________. Historical Analysis of Wartime Replacement Requirements: Experience for Selected Major Items of Combat Equipment. Report No. 14. 2 vols. Washington, D.C.: HERO, 1966.

This report examines and analyzes historical data on materiel losses in combat operations in World War I, World War II, and the Korean War. The report is based largely on primary military records and emphasizes the materiel attrition experience of selected units fighting in North Africa, Italy, Northwest Europe, and the Pacific in World War II. The research produced tabulated data on losses for units in various combat postures, and under various other conditioning factors. The analysis provides a basis for predicting equipment losses for selected major items of materiel in future warfare.

Voevodsky, John. Quantitative Behavior of Warring Nations. Systems Analysis Division Staff Study. Washington, D.C.: Department of the Navy, 1968.

This study is an investigation of the quantitative relationships between populations, army strengths in battle zones, casualties, and fatalities. It is based on historical data of major US wars from the Civil War to the Vietnam War, through 1968, and statistics of the military effort of Great Britain and France against Germany in World War I and vice versa. The author attempted to apply the quantitative patterns of repetitive behavior he discerned in the historical data to predict future trends of the then ongoing US experience in Vietnam. The analysis is vitiated by frequent misunderstandings and misinterpretations of the data, and the projections have been refuted by experience data for Vietnam since the date of publication.

Wright, Quincy. A Study of War. Chicago: University of Chicago Press, 1965.

First published in 1942, this is a classic study and analysis of war phenomena throughout history. The author compiled a massive data base touching a variety of aspects of warfare and analyzed it using techniques of the social and behavioral sciences. The work considers quantitative trends in warfare and includes a broad discussion of war casualties. The 1965 2d edition includes the author's commentary on war since 1942.

Part Two: Specific Sources

Beebe, Gilbert W., and Michael E. De Bakey. Battle Casualties: Incidence, Mortality, and Logistic Consideration. Springfield, Ill.: Charles C. Thomas, 1952.

This book is the seminal source on the casualty experience of US Army ground forces in World War II. The authors compiled the data base for their analysis from a variety of sources, including the operational records of tactical units and their medical staffs and from official records and reports of the US Army Medical Service. The analysis is most complete and includes concepts and considerations of the incidence, mortality, evacuation, and hospitalization of battle casualties. The emphasis is on World War II, but the authors include data and discussion of historical trends in personnel attrition, particularly in chapter II, "Incidence of Hits and Wounds."

Clark, Dorothy Kneeland. Casualties as a Measure of the Loss of Combat Effectiveness of an Infantry Battalion. Technical Memorandum ORO-T-289. Chevy Chase, Md.: Operations Research Office of the Johns Hopkins University, 1954.

A pioneering study of the battalion breakpoint concept, based upon actual combat data. The analysis is based on a sample population of 44 US infantry battalions involved in seven engagements in the European Theater of Operations during World War II. The author concludes that: "The statement that a unit can be considered no longer combat effective when it has suffered a specific casualty percentage is a gross over-simplification not supported by combat data."

Gilchrist, H.L. A Comparative Study of World War Casualties from Gas and Other Weapons. Washington, D.C.: Government Printing Office, 1928.

This is a text prepared by the Chief, Medical Division, US Army Chemical Warfare Service, for use in the curriculum of the Chemical Warfare School, Edgewood Arsenal. It provides a useful discussion and analysis of World War I casualties, accompanied by tables and charts. The emphasis is on gas casualties, but, as the title indicates, the analysis compares gas casualties with those caused by other agents, in the World War and in other wars. An analysis of the data given in the work was performed subsequently by Dorothy Clark, who questioned the figures on the proportion of gunshot-wounded soldiers who died, finding them much higher than those of other sources.

Great Britain. War Office. Statistics of the Military Effort of the British Empire During the Great War. London: His Majesty's Stationery Office, 1922.

This is the official compilation of statistical data relative to the military effort of Great Britain and the British Empire during World War I. It includes much data on personnel and material strengths, personnel casualties, material losses, allocations of munitions, etc., presented generally in tabular form. The data is organized usually by war theater, campaign, and time period, rarely by battle. There are summary reports of Allied and enemy strengths and casualties. Other data presented includes various war chronologies, statements on prisoners captured from the enemy, and a table showing the length, in miles, of the line held by British forces in France and Flanders at various times during the war. Little attempt is made to analyze the data presented.

Haldenwang, A. von. Statistik und Verluste. Vol. XX of Wuerttembergs Heer im Weltkrieg. Stuttgart, 1936.

As the title indicates, this is a narrow statistical and narrative summary of the military effort of one German state, that is Wuerttemberg in southwest Germany, in World War I. Discussion and tables give details of mobilization and organization and provide data on personnel strengths and casualties by arm of service for war years (that is, years beginning on 1 August of one year and ending on 31 July of the next--the war having begun for Germany on 1 August 1914) and for the period August 1918 to the Armistice. Some consideration is given to matters of logistics and the war economy.

Historical Evaluation and Research Organization (HERO). Casualty Estimates for Contingencies (CEC). Report No. 118. Fairfax, Va.: HERO, 1986.

This report examines the battle casualty experience of troops of the US and US allies in 73 selected combat engagements that occurred in conflicts since the end of World War II. The research performed for the report permitted the formulation of some important generalizations about the classification and complex nature of conflict since 1945. The analysis of the data base of 73 engagements resulted in the development of tabulations showing average battle casualty rates by casualty category and according to a variety of circumstantial (operational and environmental) factors. These tables provide useful insights for planners and modellers.

_______. Historical Survey of Casualties in Different Sized Units in Modern Combat. Report No. 97. Dunn Loring, Va.: HERO, 1982.

Personnel attrition data in four engagements of US troops in the European Theater of Operations in World War II was collected and analyzed at the level of division, regiment, and battalion and recorded in tabular form showing the strength, both by day and as an average for the period concerned, and casualties by category, both numerically and as percents of the daily strength, by day and as averages for the period. Total or cumulative casualties by category during the period are also shown. The report includes detailed narratives of the combat experience of the divisions and sub-units in each engagement, their casualty experience, and 30 tables.

_______. Physical Damage and Casualties in Conventional Battle. Report No. 93. Dunn Loring, Va.: HERO, 1982.

The report assesses physical damage and military and civilian casualties in three battles in northern Europe in World War II. It includes narratives of the battles and presents tabular data on physical damage done during the course of each battle, the strengths and losses of the opposing forces in each, and civilian casualties incident to each. Additionally, an attempt was made to relate ammunition expenditures (artillery shells and air-delivered bombs) to the level of damage assessed for each battle terrain area selected for damage evaluation. Besides the three case studies the report includes a brief chapter describing physical damage and civilian casualties in metropolitan France generally, and particularly in the departments of the Manche and Calvados (in Normandy).

Historical Division, Headquarters, United States Army, Europe. Guide to Foreign Military Studies, 1945-54. Karlsruhe, Germany, 1954.

This is a descriptive catalog and index of manuscripts prepared by former high-ranking officers of the German Armed Forces during 1945-1954 under the Foreign Military Studies Program of the Historical Division, USAREUR. The original mission of the program was to obtain information about enemy operations in the European Theater for use in the preparation of the official history of the US Army in World War II. The program's mission was later changed to emphasize operational studies and analyses of German military experience in a variety of areas. Thus, the manuscripts produced include operational summaries and analyses, unit histories, lessons learned type reports, and monographs on German experience in a diversity of areas, including organization, administration, and tactics. Because of the widespread destruction of German World War II operational records, many of the monographs have value for the attrition researcher. Some of them deal with analyses of casualty experience, and one, MS # P-011, describes the German system of reporting casualties.

Livermore, Thomas L. Numbers & Losses in the Civil War in America: 1861-65. Bloomington, Ind.: Indiana University Press, 1957.

This is a compilation of data relative to personnel strengths and casualties in the American Civil War that was first published in 1900 and is considered a classic among works of its kind. The author was a Union army veteran who rose through the ranks from private to colonel and who, subsequent to the war, was a lawyer and businessman. The data was culled from the 129-volume Official Records of the War of the Rebellion and from reliable secondary sources. The first half of the work is devoted to the presentation and explication of data descriptive of the total number of personnel who served in the opposing armies, total casualties, and a comparison of personnel casualties in similar battles. The second half of the work presents personnel strength and casualty data for specific battles. Two tables summarize the battle data.

Love, Albert G. War Casualties. The Army Medical Bulletin, No. 24, Carlisle Barracks, Pa.: Medical Field Service School, 1931.

The purpose of this work was to estimate, based on experience data, the requirements for medical services for front line casualties in a future war. It provides statistics on the incidence and treatment of battle and nonbattle casualties based mainly on the experience of US forces in World War I. Because of the book's focus on the treatment of wounded, and because World War I saw the widespread employment of chemical weapons, the author draws a useful differentiation between gas-wounded and gunfire-wounded. Since the data base is grounded mainly in US experience, which occurred largely in the last year of the war, the gas casualties are predominantly from mustard.

Neel, Major General Spurgeon. Medical Support of the U.S. Army in Vietnam, 1965-1970. Washington, D.C.: Department of the Army, 1973.

This is a monograph in the Office of the Chief of Military History's Vietnam Studies series. It discusses the experience of the US Army's Medical Department in Vietnam for the years 1965-1970. Though concerned primarily with the specifics of medical operations in the relatively unique environment and circumstances of the Vietnam War, it provides also an interesting comparative statistical analysis of quality of care of the wounded in World War II, Korea, and Vietnam, focussing on survival statistics and patient care indices. Insights into the implications of the Vietnam War casualty experience for other modern conflicts are given in discussions of wound causative agents, the nature of wounds and the mechanics of wounds caused by modern weapons, and medical advances.

Peckham, Howard H., ed. The Toll of Independence: Engagements & Battle Casualties of the American Revolution. Chicago: University of Chicago Press, 1974.

This book lists 1,331 land, and 218 naval engagements and actions of the American Revolutionary War and American and British battle casualties by category in each. Each engagement is briefly described, and the strengths of the opposing forces, where known, are given. This is a very careful compilation, assembled using primary and secondary sources by a research team guided by the director of the William L. Clements Library at the University of Michigan. The introduction contains a useful description of the methodology employed in the effort to amass the data and analyze it for reliability.

Reister, Frank A. Battle Casualties and Medical Statistics: U.S. Army Experience in the Korean War. Washington, D.C.: The Surgeon General, 1973.

This is a very significant compilation and analysis of data relative to the casualty experience of the US Army in the Korean War, 1950-1953. Like the work of Beebe and De Bakey (q.v.), on which it was modelled, it was compiled to provide medical planners with statistics and factors from historical experience to forecast future requirements. The text, which is complemented by numerous presentations, provides discussion and analysis of casualty and morbidity experience, effects of type of operation and tactical action on casuality rates, weapons' lethality, wound location, hospitalization and evacuation experience, and surgical, medical, and logistic considerations.

Stanton, Shelby L. Vietnam Order of Battle. Washington, D.C.: U.S. New Books, 1981.

This is a detailed, encyclopedic discussion of the US Army's Vietnam War order of battle and related subjects that is based on official records and documents. Appendix C provides a tabular presentation of summary data on US personnel casualties and materiel losses (selected items of equipment) incident to the war.

Thayer, Thomas. The U.S. in Vietnam: War Without Fronts. Boulder, Col.: Westview Press, 1985.

This is a quantitative analysis of significant aspects of US troop involvement in the Vietnam War from 1965 to 1972. The author made use of formerly classified information collected from the military command in Vietnam and examined, interpreted, and analyzed for planning and decision-making processes by Defense Secretary MacNamara's Systems Analysis team, for which he worked as analyst. Part 3, "The Casualty Toll," is an informed discussion, with tabulations of data, of Vietnam War casualty experience. There is a brief, enlightening discourse on the "accuracy problem" respecting allied KIA estimates for VC/NVA troops. This book is recommended as a model of the quantitative analysis of various data generated by war experience, and will be particularly valuable to the attrition researcher, since it provides exemplars of the kinds of trends and relationships that can be discerned from a mass of raw data.

Appendix 1

HIERARCHY OF COMBAT

An understanding of combat phenomena is facilitated by using a hierarchy of combat to describe combat events and aggregate them for analysis. The hierarchy of combat which is commonly accepted is as follows: war; campaign; battle; engagement; action; and duel.

The hierarchy of combat has been adopted by the Military Conflict Institute as part of its effort to standardize and simplify terminology relating to combat. HERO has proposed the insertion of the level of "action" between engagement and duel, and the term action is included in this statement of the hierarchy. The levels of combat are defined as follows:

War is armed conflict, or a state of belligerence, involving military combat between two factions, states, nations, or coalitions. Hostilities between the opponents may be initiated with or without a formal declaration that a state of war exists. A war is fought for a stated particular political or economic purpose or reason, or to resist an enemy's efforts to impose domination. A war can be short, sometimes lasting a few days, but usually is lengthy, lasting for months, years, or even generations.

A campaign is a phase of a war involving a series of military operations related in time and space and aimed toward achieving a single, specific, strategic objective or result in the war. A campaign may include a single battle, but more often it comprises a number of battles, connected over a protracted period of time or a considerable distance, but within a single theater of operations or delimited area. A campaign may last only a few weeks but usually lasts several months or even a year.

A battle is combat between major forces, each having opposing assigned or perceived operational missions; each side seeks to impose its will on the opponent by accomplishing its own mission, while preventing the opponent from achieving his. A battle starts when one side initiates combat and ends when one side accomplishes its mission or when one or both sides fail to accomplish the mission(s). Battles are often part of campaigns. Battles last from a few days to several weeks.

An engagement is combat between two forces, neither larger than a division nor smaller than a company, in which each has an assigned or perceived mission, which begins when the attacking force initiates combat and ends when the attacker has accomplished its mission, or ceases to try to accomplish the mission, or one or both sides receive significant reinforcements, thus initiating a new engagement. An engagement is often part of a battle. An engagement normally lasts one or two days; it may be as brief as a few hours and is rarely longer than five days.

An action is combat between two forces, neither larger than a battalion nor smaller than a squad, in which each side has a tactical objective, which begins when the attacking force initiates combat and ends when the attacker seizes the objective, or one or both forces withdraw, or both forces terminate combat. An action is often part of an engagement and is sometimes part of a battle. An action lasts for a few minutes or a few hours and never lasts more than one day.

A duel is combat between two individuals or between two mobile fighting machines, such as combat vehicles, combat helicopters, and combat aircraft, or between a mobile fighting machine and a counter-weapon. A duel starts when one side opens fire and ends when one side or both are unable to continue firing or stop firing voluntarily. A duel is almost always part of an action. A duel lasts only a few minutes.

Appendix 2

EXAMPLE OF ATTRITION RESEARCH

An example of how official documents are used in attrition research is provided by work performed by HERO researchers in an investigation of the casualty experience of the US 30th Infantry Division in the Battle of Mortain, fought in Normandy during 6-12 August 1944. Research in the division's operational records was performed at the Federal Records Center, Suitland, Maryland.

The strength of the division and its subordinate and attached units on the eve of the battle was determined from inspection of the division's G-1 (Personnel) Periodic Report dated 2400 hours 5 August 1944. Figure 68, adapted from the original, shows how this data appears in the record.

Figure 68

US 30th Infantry Division, Strength of Command as of 2400B 5 August 1944

Subordinate Unit	Authorized Strength Off./WO	Authorized Strength EM	Present For Duty Strength Off./WO	Present For Duty Strength EM
Div HQ	53	106	57	124
Hq Sp Trs	5	20	5	19
Hq Co	6	154	6	162
MP Plat	3	68	4	99
730th Ord Co	10	131	10	135
30th QM Co	10	175	9	199
30th Sig Co	13	226	14	255
30th Rcn Tr	6	143	3	125
117th Inf Regt	157	3049	127	2485
119th Inf Regt	157	3049	153	2518
120th Inf Regt	157	3049	122	2013
Hq Btry Arty	20	104	22	110
197th FA Bn	33	468	31	468
118th FA Bn	33	468	34	468
230th FA Bn	33	468	26	466
113th FA Bn	32	487	31	486
105th Engr Bn	32	603	30	577
105th Med Bn	37	407	37	404
Div Totals	797	13,175	721	11,143
Attached Units*				
823d TD Bn	34	729	30	652
531st AAA AW Bn	38	744	38	746
743d Tk Bn	35	665	40	663
629th TD Bn	36	635	34	603

*Very small or insignificant attached units deleted from listing.

The G-1 (Personnel) Periodic Reports also recorded casualties and replacements. A typical line entry for Casualties in Period provides the data in Figure 69.

Figure 69

US 30th Infantry Division, Casualties in Period 2400B 5 August to 2400B 12 August 1944.

Subordinate Unit	Battle Cas. (BC)	Non-battle Cas. (NBC)	Total Cas.
117th Inf Regt	323	195	518

The data is presented in a format that categorizes casualties as killed, wounded, missing or captured (BC), or sick, evacuated, and non-evacuated (NBC). This form also shows replacements received and expected in the period.

Casualties incurred by units each day and replacements forwarded to units each day are shown on the Daily Estimated Loss Reports.

Careful exploitation of these personnel records allowed the researchers to build a complete picture of the attrition history of the division both during the period of the battle (it happened that the term of the G-1 [Personnel] Periodic Reports used coincided exactly with the duration of the battle) and on a daily basis.

These records are located at the Federal Records Center, Suitland, Maryland, in Record Group 407, Box 8733, 330-1.2 30th Inf. Div. G1 Journal, August 1944.

Appendix 3

THE PROCESS OF HISTORICAL CRITICISM

In order to assess the reliability of strength and attrition data from both primary and secondary sources, it is necessary to perform the process of historical criticism. This is similar to the process used commonly to assess the reliability and credibility of any piece of information used in the intelligence cycle.

The analyst must first understand thoroughly the conflict for which the data is being reported. This requires the following: a narrative of the engagement, battle, or campaign; a map; and orders of battle for the opposing sides. With these the researcher or analyst will have the basis for acquiring an understanding of the event, which includes who (what units) was involved, what happened, when it happened, where it happened, and, perhaps, why it happened.

Once the analyst becomes familiar with the combat events he is investigating he can evaluate the available data. This process involves a rigorous assessment of the evidence in order to establish its reliability, as a basis for further work.

The first step is to establish the authenticity of the document. In this step it would be well to remember that there have been numerous historical frauds and fake documents, some of which have gained widespread acceptance. An example of this phenomenon was the notorious Protocols of the Elders of Zion. Other examples include propaganda pieces produced by governments or government agencies for their own ends, like the British bluebook describing German atrocities in Belgium in 1914 or current KGB disinformation pieces.

Once the authenticity of a document has been established the truthfulness of the information it contains must be assessed. In doing this the analyst considers the document in the light of several questions. These may be divided into two general areas: external criticism and internal criticism.

External criticism is concerned with factors external to the content of the document itself, principally the factors surrounding its creation. Some typical questions asked in this stage are as follows:

> When was the document created?
>
> Who was the author?
>
> Why was the document created?
>
> Is there any reason to suppose that the author might have been biased or prejudiced in his presentation of the facts?
>
> Is there any reason to believe that the author might have deliberately or inadvertently misrepresented or distorted the facts?
>
> What have other analysts said about the reliability of the document?

Internal criticism is concerned with the content of the document in question. Some questions that may be asked in this stage are as follows:

> Was the author in a position to know all that he relates?
>
> What evidence presented in the document may be regarded as fact? As opinion?
>
> Does the data presented make sense in general?

Does the data presented accord with what we know of the event from other sources?

Many more specific questions may be asked at this stage of the inquiry. The tests involved are very like those involved in a court of law, where the court considers the admissibility of evidence (a matter of law, decided by the judge), and the jury weighs the evidence to determine the facts and arrive at a verdict.

Historical criticism is hard work which can be accomplished only by acquiring a thorough familiarity with the subject under investigation and adhering consistently to a sound methodology.

Appendix 4

ASSESSING RELATIVE COMBAT EFFECTIVENESS

By using the Quantified Judgment Model (QJM) HERO is able to assess the relative combat effectiveness of opposing forces in historical battles and engagements. The QJM process involves the calculation of two ratios.

The Combat Power Ratio is based on the strength, weapons, and circumstances of opposing forces in a battle. The Result Ratio is based upon the outcome of the battle.

The Combat Power, P, of each opponent is obtained by calculations in which factors representing the effects of the environmental and operational circumstances are applied to the Force Strengths of each side. The Combat Power Ratio is obtained by dividing the P for one side, P1, by the P for the other side, P2. The ratio P1/P2 defines the theoretical outcome of a battle. If P1/P2 is greater than 1.0, then Side 1 should have been successful; if the ratio is less than 1.0, then Side 2 should theoretically have won.

The actual outcome of a historical battle is described by a Results Ratio, R1/R2. If R1/R2 is greater than 1.0, Side 1 actually won; if R1/R2 is less than 1.0, Side 2 was successful. Unless the two sides were perfectly matched in capability (something which has occurred rarely in history) P1/P2 is practically never identical to R1/R2, although it may be close.

The relative Combat Effctiveness Value (CEV) of the opposing sides is defined as the ratio of R1/R2 to P1/P2, or:

$$CEV1 = (R1/R2)/(P1/P2)$$

At the Battle of Austerlitz the Combat Power Ratio of

Napoleon's outnumbered French army with respect to the Austro-Russian Allied Army was: Pfr/Pal = 0.94. Before the battle an objective observer would have expected that Napoleon would have been defeated in a close-fought battle. However, the Results Ratio for this battle was Rfr/Ral = 2.02. The CEV for the French is calculated as follows:

CEVfr = 2.02/0.94 = 2.15

In other words, the quality of Napoleon's leadership combined with the excellence of his Grand Army, meant that 100 French troops were the equivalent of more than 200 Allied troops.

By examining the outcomes of some 200 historical engagements of the 20th Century, HERO discovered that the ratio of the casualty-inflicting rates of the opposing sides in these battles was usually very close to the square of the CEV.

Let's see how this fits with the assessment of the relative quality of the troops, and the outcome of the Battle of Austerlitz. Napoleon had 75,000 troops, and suffered 7,000 casualties, a casualty rate of 9.33%. The Allies had 89,000 troops, and lost 27,000 men, a rate of 30.33%. However, the rate at which 75,000 French troops inflicted 27,000 casualties is 0.36 casualties inflicted by every French soldier. The 89,000 allies, on the other hand, inflicted 7,000 casualties at the rate of 0.08 casualties for every Allied soldier. That produces a <u>casualty-inflicting</u> ratio of 4.5 to 1.0 in favor of the French (0.36/0.08). The French CEV, calculated above, was 2.15; the square of the CEV is 4.62, which is very close to the 4.5 ratio of the casualty-inflicting ability of the opponents.

Napoleon once remarked that "the moral is to the physical as three is to one." It would seem from the HERO data, however, that the moral is the equivalent of the physical squared.

While, on the average, the ratio of the casualty-inflicting capability of two opponents in any given battle is approximately the square of the CEV, there can be substantial deviation from this average in individual cases. Nevertheless, one can very cautiously and very tentatively assess the relative combat effectiveness of opposing forces if one has enough data to calculate with reasonable confidence the general ability of the two sides to inflict casualties upon each other in one or (preferably) more battles.

Appendix 5

73-ENGAGEMENT POST-1945 CONFLICT DATA BASE

Engagement Number	Conflict Type	Conflict; Date; Engagement Name
450601	EI	Indonesia, 11-14 Mar 1946: Ambush of British Convoy
450801	EI	French Indochina War, 4-6 Dec 1953: Operation CANTER I
450802	EI	French Indochina War, 29 Jun 1954: Ninh Binh
450803	EI	French Indochina War, 1 Jul 1954: My Coi
460402	EI	Greece, 18/19 Apr 1947: Agrafa-Viniani
460403	EI	Greece, 26 May 1947: Mount Vermion
460405	EI	Greece, 25 Jul 1947: Grevena
460406	EI	Greece, 12-15 Feb 1949: Florina II
520100	MH	Egypt, 25 Jan 1952: Operation EAGLE
520401	EI	Cyprus, 18-29 May and 8-23 Jun 1956: Operations PEPPERPOT and LUCKY ALPHONSE
540201	EI	Algeria, 27 Jan-15 Apr 1957: Battle of Algiers
540202	EI	Algeria, 23-24 May 1957: Battle of Agounnenda
540203	EI	Algeria, 21 Nov 1957: Hassi Rhambou
560101	W	Sinai, 29/30 Oct 1956: Battle of Kuseima
560102	W	Sinai, 30 Oct 1956: Battle of Thamad
560103	W	Sinai, 30 Oct 1956: Battle of Nakhl
560104	W	Sinai, 30 Oct-2 Nov 1956: Battle of Um Sheham-Um Katef
560108	W	Sinai, 1-2 Nov 1956: Battle of Bir Rud Salim-Bir Gifgaf
560109	W	Gaza Strip, 2-3 Nov 1956: Battle of the Gaza Strip
560110	W	Sinai, 4-5 Nov 1956: Battle of Sharm el Sheikh
560201	W	Egypt, 5 Nov 1956: Port Fuad-Port Said
560202	W	Egypt, 5 Nov 1956: Gamil Airfield

570101	EI	Oman, 6-11 Aug 1957: Nizwa Drive
570102	EI	Oman, 26 Jan 1959: Jebel Akhdar
570501	MH	Morocco, 23 Nov 1957: Sidi Ifni
600101	MH	Congo, 10 Jul 1960: Luluabourg
600102	MH	Congo, 11 Jul 1960: Matadi
600103	MH	Congo, 13 Jul 1960: N'djili Airport
600104	MH	Congo, 17 Jul 1960: Boende
600105	MH	Congo, 17 Jul 1960: Bunia
600106	MH	Congo, 19 Jul 1960: Advance to Mongbwalu
600201	EI	Congo, 15-16 Dec 1960: Rescue of Austrian Medical Team at Bukavu
600202	EI	Congo, 11 Feb-11 Apr 1961: Katangan Government Pacification Operations
600203	EI	Congo, 3-6 Mar 1961: Incidents Between ANC and UN Troops at Banana, Matadi, and Kitona
600204	EI	Congo, 13-21 Sep 1961: Elisabethville
600205	EI	Congo, 5-6 Dec and 15-19 Dec 1961: Fighting Between Katangan and UN Troops I
600206	EI	Congo, 28 Dec 1962-21 Jan 1963: Fighting Between Katangan and UN Troops II
610201	MH	Tunisia, 19-20 Jul 1961: Sidi Ahmed Airbase
610202	MH	Tunisia, 21-22 Jul 1961: Bizerta Engagement
620101	EI	Vietnam, 20 Jul 1966: Operation SYDNEY II
620102	EI	Vietnam, 18 Aug 1966: Battle of Long Tan
620104	EI	Vietnam, 10 Feb-19 Mar 1970: Operation HAMMERSLEY
620105	EI	Vietnam, 6 Mar-25 Apr 1971: Operation BRIAR PATCH I
621101	EI	Oman, 19 Jul 1972: Mirbat
630201	EI	Aden, 11 May-11 Jun 1964: Radfan Campaign
630202	EI	Aden, 23/24 Aug 1964: Operation TEST MATCH
630203	EI	Aden, 20 Jun 1966: Recapture of Federal Guard Camp/Crater Police Barracks

640100	MH	East Africa, 20-27 Jan 1964: Suppression of East African Armies Mutinies
640200	MH	Gabon, 18-19 Feb 1964: Libreville
640501	MH	Congo, 23 Nov 1964: Operation DRAGON ROUGE, Van de Waele Column
640502	MH	Congo, 24-25 Nov 1964: Operation DRAGON ROUGE, Paradrop/ Air Landing
640600	MH	Congo, 26-27 Nov 1964: Operation DRAGON NOIR
670101	W	Sinai, 5-9 Jun 1967: Shadni Brigade Operations
670102	W	Jerusalem Sector, 6-7 Jun 1967: Israeli Parachute Brigade Operations
680100	MH	Kerama, Jordan, 21 Mar 1968: Operation TOFFET
730101	W	Golan Heights, 6-11 Oct 1973: Barak Brigade Operations
750200	MH	Saigon, South Vietnam, 29/30 Apr 1975: Operation FREQUENT WIND
750300	MH	Cambodia, 15 May 1975, Mayaguez Rescue Operation
760100	MH	Uganda, 3/4 Jul 1976: Operation JONATHAN
770100	MH	Somalia, 18 Oct 1977: Operation MAGIC FIRE
780100	MH	Lebanon, 14-20 Mar 1978: Litani River Operation
780301	MH	Zaire, 19 May 1978: Operation LEOPARD, Parachute Drop
780302	MH	Zaire, 20 May 1978: Operation LEOPARD, Metal Shaba
780303	MH	Zaire, 22 May 1978: Operation LEOPARD, Kapata I
780304	MH	Zaire, 23 May 1978: Operation LEOPARD, Luilu I
820101	W	Falkland Islands War, 21 May 1982: San Carlos Landing
820102	W	Falkland Islands War, 27 May 1982: San Carlos Beachhead
820103	W	Falkland Islands War, 28-29 May 1982: Darwin and Goose Green Engagements
820104	W	Falkland Islands War, 11/12 and 13/14 Jun 1982: Port Stanley Engagment
820201	W	Lebanon, 6-11 Jun 1982: Operation PEACE FOR GALILEE, Western Sector

820202	W	Lebanon, 6-11 Jun 1982: Operation PEACE FOR GALILEE Armored Task Force "C-1"
820203	W	Lebanon, 7-11 Jun 1982: Operation PEACE FOR GALILEE Central Sector
820204	W	Lebanon, 9-11 Jun 1982: Operation PEACE FOR GALILEE Eastern Sector

TABLE A: THEATER ANNUAL AND DAILY CASUALTY RATES: US WARS, WORLD WAR I, AND WORLD WAR II

	Average Theater Strength	Total Casualties	Average Annual Casualties	Average Annual Casualty Rate - %	Average Daily Casualty Rate - %
US Army					
Mexican War, 1846-48	25,000	4,947	2,474	9.90	0.03
Civil War, 1861-65	400,000	388,182	97,046	24.26	0.07
Spanish-American War, 1898	50,000	1,872	2,808	5.62	0.02
Philippine Insurrection, 1899-1903	50,000	3,961	1,320	2.64	0.01
World War I, 1918 (6 months)	990,000	261,657	523,314	52.86	0.14
World War II, 1942-45	1,500,000	800,735	266,912	17.79	0.05
Korean War, 1950-53	220,000	97,141	32,380	14.72	0.04
Vietnam War, 1966-71	240,000	170,093	34,019	14.17	0.04
World War I					
United States	990,000	261,657	523,314	52.86	0.14
British Empire	1,750,000	2,998,583	749,646	42.83	0.12
France	3,000,000	5,623,800	1,405,950	46.87	0.13
Russia	3,500,000	6,650,000	2,216,667	63.33	0.19
Germany	3,250,000	6,055,688	1,513,922	46.58	0.13
Italy	1,000,000	1,416,277	472,042	47 20	0.13
World War II					
United States	1,500,000	800,735	266,192	17.75	0.05
United Kingdom	1,000,000	872,672	174,552	17.46	0.05
France	1,250,000	610,671	203,557	16.28	0.04
USSR	6,100,000	21,512,000	5,378,000	88.16	0.24
Germany	4,500,000	10,100,000	2,020,000	44.89	0.12
Italy	500,000	197,500	98,750	19.75	0.05
Japan	2,000,000	2,006,000	501,500	25.08	0.07
China	3,000,000	2,200,000	367,000	12.23	0.03

TABLE B:

SELECTED DAILY CASUALTY RATES IN BATTLES OR ENGAGEMENTS (1861-1982)

	Year	Average Strength	Average Daily Casualty Rate %
American Civil War, 8 Battles			
Union	1861-65	68,250	11.5
Confederacy	1861-65	50,193	15.0
World War I			
German Divisions, 9 Engagments	1915	18,133	5.7
British Divisions, 9 Engagements	1915	13,628	8.5
US Divisions, Overall Average	1918	28,000	2.0*
US Bde Slice, Overall Average	1918	14,000	4.0*
World War II			
US Divisions, Overall Average	1943-45	14,000	0.9*
US Divisions, 82 Engagements	1943-44		1.2*
German Divisions, 82 Engagements	1943-44		1.8
German Divisions, Overall Average	1941-45	12,000	2.0*
German Corps, Kursk, 3 Engagements	1943	58,000	1.1
Soviet Army, Kursk, 3 Engagements	1943	85,000	3.0**
Korean War			
US Divisions, Overall Average	1950-53	15,000	0.8*
Six-Day War			
Israeli Units, 21 Engagements	1967	12,232	2.8
Egyptian Units, 11 Engagements	1967	14,245	6.0
Jordanian Units, 5 Engagements	1967	8,750	5.6
Syrian Units, 4 Engagements	1967	11,371	4.0
October War			
Israeli Units, 33 Engagements	1973	14,593	1.8
Egyptian Units, 16 Engagements	1973	34,321	2.6
Syrian Units, 17 Engagements	1973	16,975	2.9
Lebanon			
Israelis vs Syrians, 2 Engagements	1982	31,000	1.2
Syrians vs Israelis, 2 Engagements	1982	27,500	5.0**
Israelis vs PLO (4 days)	1982	28,000	0.2
PLO vs. Israelis (4 days)	1982	8,000	13.1**

* Approximate, more research required
** Estimated

TABLE C:

US ARMY CASUALTIES IN WARS OF THE 19TH AND 20TH CENTURIES

	Total Mobilized	Average Theater Strength	KIA	WIA	Total Casualties	DOW	Surviving Wounded	Battle Deaths	Disease Deaths	Non-Battle Injury Deaths	Total Non-Battle Deaths	Total Deaths
Mexican War 2 Years	116,597	25,000	1,049	3,898	4,947	508	3,390	1,557	10,982	395	11,377	12,934
US Civil War 4 Years	2,898,304	400,000	69,982	318,200	368,182	44,775	273,425	114,757	233,789	10,982	244,771	359,528
Sp.-American War 8 Months	280,564	50,000	272	1,600	1,872	107	1,493	379	4,795	288	5,083	5,462
Philippine Ins. 3 Years	125,468	50,000	823	3,138	3,961	241	2,897	1,064	4,874	1,063	5,937	7,001
World War I 6 Months	4,057,101	990,000	37,568	224,089	261,657	13,691	210,398	51,259	51,447	4,421	55,868	107,127
Excluding Gas Casualties		990,000	36,568	153,567	190,135	12,470	141,047	49,038				
World War II 3 Years	11,260,000	1,500,000	175,407	625,328	800,735	59,467	565,861	234,874	14,243	50,976	65,219	240,626
Excluding USAAF		1,000,000	142,334	604,812	747,146	55,762	549,050	198,096				
Korean War 3 Years	2,834,000	220,000	19,353	77,788*	97,141	1,957	75,831	21,310	509	2,243	2,752	23,762
Vietnam War 5 Years	4,368,000	240,000	23,373	104,032**	127,405	7,222	96,810	30,595	1,422	5,828	7,250	37,845

*Does not include Coded for Record Only (CRO), individuals who were "treated and returned to duty immediately."
**Includes all DOW (Died of Wounds), which in turn includes dead while missing and MIA.

TABLE D

US ARMY WORLD WAR I OVERSEAS STRENGTHS AND CASUALTIES

BY BRANCH AND RANK*

	STRENGTH				PERCENTAGES		
	Officer	Enlisted	Total**	Casualty Total	Branch Strength as % of Total Strength	Branch Cas. as % of Total Casualties	Branch Cas. as % of Branch Strength
nfantry	26,465	619,525	646,000	229,223	48.8	87.9	35.5
ank Corps	976	9,224	10,200	454	0.8	0.2	4.5
rtillery	14,950	263,550	278,500	11,146	21.0	4.3	4.0
ngineers	3,126	78,474	81,600	8,456	6.2	3.2	10.4
ed. Dept.	19,600	132,700	152,300	3,954	11.5	1.5	2.6
ther	7,583	148,217	155,800	7,550	11.7	2.9	4.8
Total	72,710	1,251,690	1,324,400	260,783	100.0	100.0	19.7
	(5.5%)	(94.5%)	(100%)				
ir Service***	5,300	38,900	44,200	685	3.3	0.3	1.5

*Based on Army Almanac, pp. 432, 433, 666

**November 11, 1918

***Included under "Other"

TABLE E:

US ARMY WORLD WAR I

BATTLE DEATHS BY BRANCH AND RANK*

	Officer	Enlisted	Total
Infantry	2,822	42,429	45,251
Tank Corps	11	49	60
Artillery	142	1,729	1,871
Engineers	86	1,228	1,314
Med. Dept.	47	363	410
Air Service	130	172	302
Others	65	1,112	1,177
Total	3,303	47,082	50,385
	(6.56%)	(93.44%)	(100%)

*Based on Leonard P. Ayres, The War With Germany: A Statistical Summary, Government Printing Office, Washington, D.C. 1919, p. 121, and Army Almanac, p. 666.

TABLE F

US ARMY WORLD WAR II OVERSEAS STRENGTHS AND CASUALTIES BY BRANCH AND RANK

(TYPICAL 12 MONTHS OF 40 MONTH PERIOD FROM DECEMBER 1941 TO MARCH 1945)

	Strengths			Casualties			Branch Strength as % of Total	Percentages of Casualties			Branch Cas. as % of Total
	Officer	Enlisted	Total	Officer	Enlisted	Total	Strength	Officer	Enlisted	Total	Cas.
Infantry	40,872	716,840	757,712	10,509	189,891	200,400	21.9	25.7	26.5	26.4	80.3
Armor*	3,820	45,696	49,516	648	8,045	8,704	1.4	17.0	17.6	17.6	3.5
Field Artillery**	19,275	259,524	278,799	1,638	12,461	14,099	8.1	8.5	4.8	5.1	5.6
Med. Dept.	40,696	257,899	298,595	374	6,886	7,260	8.7	0.9	2.7	2.4	2.9
Engineers	21,129	385,445	406,574	592	8,403	8,994	11.8	2.8	2.2	2.2	3.6
Air Defense & Coast Artillery	26,491	454,299	480,790	281	4,407	4,688	13.9	1.1	1.0	1.0	1.9
Other	29,869	1,149,237	1.179,106	1,075	4,367	5,442	34.2	3.6	0.4	0.5	2.2
Totals	162,152 (5.3%)	3,268,940 (94.7%)	3,451,092 (100 %)	15,117 (6.1%)	234,460 (93.9%)	249,577	100.0	8.3	7.2	7.2	100.0
USAAF	405,852 (16.5%)	2,058,606 (83.5%)	2,464,458 (100%)	14,570 (41.7%)	20,380 (58.3%)	34,950		3.6	1.0	1.4	
Grand Totals				29,687 (10.4%)	254,840 (89.6%)	284,527					

*Includes Armor and Cavalry

**Includes Chemical Warfare (because of 4.2" mortars)

TABLE G

HISTORICAL DATA FROM 595 LAND BATTLES, 1600-1973

	1600-1699	1700-1799	1800-1860	1861-1899	1900-1938	1939-1945	1967-1973	Total
Numbers of Battles	47	65	55	71	142	162	53	595
Attacker Percentages								
Successful	77	59	56	49	59	66	66	61
Surprise	30	29	20	21	30	17	42	26
Surprise & Success	79	75	55	53	91	79	73	77
Stronger	36	40	44	66	75	90	45	65
Fewer Casualties	55	46	51	39	58	69	76	58