

1. A Preliminary, Interpretive Survey of the History of Command and Control (2 Volumes) (1963) (Sandia) - Pages: 113 
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- 55A. Artillery Fire and Effect, US Ninth Army, Roer River Crossing, Feb 1945 (1977) (DNA) - Pages: 7 

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A PRELIMINARY, INTERPRETIVE SURVEY OF THE HISTORY
OF COMMAND AND CONTROL

Contractor for U. S. Atomic Energy Commission

FOREWORD

The Historical Evaluation & Research Organization of Washington, D.C. was requested to conduct a preliminary examination of command and control in military history to ascertain the extent to which history could be helpful in understanding our present day problems, particularly relating to permissive links.

Study "Pre-Alert" examines the spectrum of command and control exercised through the centuries; it investigates decision-making processes in warfare; and contains a survey of weapons and weapon systems.

The group of military historians who made this exploratory study feels that it demonstrates that military history is relevant to modern problems of military leadership, command and control, and decision-making. Even though this may be true it does not furnish any significant insight into today's design problems. It is believed, however, that the study will prove interesting to those people who are concerned primarily with the "hardware" of command and control.

Much credit is due J. L. Dossey and G. R. Ellison for their assistance during the formative stages of this research project.

H. T. STUMP

Advanced Systems Studies
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PREFACE

The primary purpose of Study "Pre-Alert" is to undertake a preliminary investigation of the extent to which historical example and experience can provide useful guidance to Sandia Corporation in the development of devices and measures designed for command and control of weapon systems. In particular, the study is intended to be relevant to procedures which will assure "foolproof" automatic controls which will prevent accidental or unauthorized employment of a weapon system without danger that such controls might be so complicated, or involve such inhibitions to individual initiative, as to preclude adequate military response by the weapon system in the event of unforeseen conditions or circumstances.

In undertaking this study, we have examined theoretical concepts of command and control in the context of brief but comprehensive surveys of the history of weapon systems, of command and control systems, and of political involvement in command and control. In addition, we have evaluated the general applicability of historical experience--particularly in the 20th Century--to modern problems of military decision-making in land, naval, and air warfare.

Study "Pre-Alert" was initiated on the assumption that historical experience is relevant to contemporary problems of decision-making in combat or in expectation of combat. Our preliminary research, as presented in this report, clearly attests the validity of this assumption.

Accordingly, we have prepared specific recommendations for further, more intensive investigation of the subject. This proposed examination, which we have titled Study "Alert", will analyze selected historical case studies for the purpose of reaching conclusions peculiarly relevant to modern problems of command and control. Special emphasis will be given to the human factor in the chain of command and to the relative importance of control and individual initiative.

Study "Pre-Alert" reflects the collaborative efforts of the following members of the HERO Associate and Permanent Staffs: Trevor N. Dupuy, Stanley L. Falk, Richard M. Leighton and Charles B. MacDonald. Useful and substantive contributions were made by the following members of a review group of HERO Associates: Martin Blumenson, R. Ernest Dupuy, William R. Emerson, Paul Y. Hammond, Maurice Matloff, Louis Morton,

Theodore Ropp, and Frank N. Trager. Dr. Franklin P. Kilpatrick of the Brookings Institution was a Special Consultant and a member of the review group. The report was edited by R. Ernest Dupuy with the assistance of Robert M. Langdon and Mary M. Hoyt.

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Part One

THE RELEVANCE OF HISTORICAL EXPERIENCE TO MODERN

COMMAND AND CONTROL

Historical Trends

During the greater part of recorded history, the development of new weapons and of doctrinal concepts for their use in combat evolved gradually, taxing man's ingenuity, but seldom requiring sudden or drastic changes either in method or in direction. In the past century and a half, however, the range, scope, and destructiveness of war have increased in ever-accelerating curves, to pose unprecedented challenges to military men, to political leaders, and to mankind in general.

Yet despite these tremendous changes in methods and means, the most common denominator of warfare remains man himself, whose basic nature has not changed in significant degree over the course of history. Furthermore, revolutionary and unprecedented as most modern military developments have been, ours is not the first age in history when man has faced sweeping innovations in the implements and techniques of warfare.*

In early primitive military organizations, a commander's control was limited to small forces of men whose actions he could personally direct and whose movements were within range of his voice and hand signals. Discipline, where it existed, stemmed from a personal fear of, or respect for, a leader who normally exercised command through physical strength or bold example. Over the years, the size, sophistication, and operational range of military units increased; and with these increases arose requirements for commanders to transmit orders and to exercise control by means of messengers, flag or smoke signals, trumpet or drum beats, and, eventually, subordinate commanders and rudimentary personal staffs. Group allegiance and social cohesiveness facilitated the training and discipline required for evolving command and control doctrine as tactical units changed from tightly controlled, solid mass formations to more flexible, mobile ones and as gunpowder weapons made their appearance.

See Appendix B for a survey of the history of weapons and weapons systems; also see Appendix C for a survey of the history of command and control in warfare, and Appendix D for a survey of political involvement in military command.

Similar developments occurred in naval warfare. There was a transition from the actions of individual, oar-propelled vessels, operating close to shore and commanded by voice or by a wave of the arm, to broader, high-seas maneuvers of sailing ships, directed by flag hoists or other signals.

At the turn of the 19th Century, the requirements for effective command and control multiplied at a rate never before experienced. With the increase in the size of field armies (which began during the Napoleonic period), strains were imposed on existing control mechanisms; in addition, increased firepower capabilities forced military units into widely dispersed formations which, in turn, decentralized and dislocated command. Steam propulsion greatly enhanced mobility on land and inland waterways, vastly extending the geographical scope of military operations. The telegraph and more sophisticated methods of military signalling kept the commander in contact with his widespread forces. By the same token, his communications procedures and command relationships became more complicated. Although the introduction of the military staff system assisted him, the staff decentralized and diluted his individual influence. Personal leadership by a commander in chief, the rule in earlier generations, was no longer feasible; operational control in general, and battle control in particular, passed increasingly to subordinates. In the tactical unit alone did personal command endure--but armies now contained hundreds or thousands of tactical units, and as many commanders.

At sea, similarly, technological developments allowed greater flexibility in maneuver, spread the geographical range of practical operations, and shortened the reaction time during which subordinate commanders could safely respond to opportunity or necessity. Control, on the one hand improved by better communications and other linkage mechanisms, was at the same time dissipated.

By the 20th Century, the commander in chief no longer commanded or controlled his forces in person. Rather, he exercised general direction, leaving considerable freedom of action to on-the-spot subordinate commanders or staff representatives. This was desirable, to a large extent, since increasing numbers, size, and dispersal of subordinate units made it important that initiative on the part of their respective leaders be encouraged. But the commander in chief still depended on firmly established doctrine to prevent substantial deviations from the over-all objectives laid down in his directives. Even more significantly, in light of the trend toward the growing scope and destructiveness of war, the commander in chief had to be increasingly concerned with the possibility of faulty execution on part of subordinates.

Similarly, as the possible consequences of acts of war have increased in scope and gravity, there has been growing civilian-political concern about the problems and dangers inherent in the employment of military force for political ends. This has led to closer political supervision over, and to some direct involvement in, military command issues in war, as well as in peacetime crises.

The advent of nuclear weapons, and of long-range rocket missiles which can accurately deliver them between continents in minutes, exemplifies the dilemma which current trends pose to political and military leaders. To what extent can a command and control system, under modern conditions, permit individual initiative in the process of military decision-making? And what are the consequences if individual initiative is inhibited?

Some Theoretical Considerations

Relationship of Doctrine and Control

Historically, the relationship between military doctrine and control systems has been both subtle and unstable. Only in part is that relationship the familiar human one between concept and practice, in which the idea either leads or follows, depending on whether it represents creative innovations or tardy adjustment of thought to action. Doctrine is not concept, per se, but rather idea that has been formalized and institutionalized and embedded in systematized practice. Its normal relationship to a control system is, therefore, one of harmony, almost identity. However, blending doctrine into system does not always produce harmony. History contains examples of persisting outmoded doctrine, enshrined in obsolete texts like, for example, the ancient Roman treatises on war, which the Middle Ages continued to read and revere but, in practice, ignored. Conversely, every great military innovator has faced, and had to compromise with, the problem of translating ideas into systematized practice. The great field service regulations of history, from the Ars militaris of the 6th-Century Byzantine Emperor Maurice to the controversial British Army Field Service Regulations of the early 20th Century, were imposed on existing systems which adjusted sluggishly to new precepts.¹

Military doctrine has, moreover, a dual aspect. It has been defined as "principles, policies and concepts which are combined into an integrated training system for the purpose of governing, and assuring consistent, coordinated employment of all components of a military force in combat."² Doctrine is thus at once integral and external to any military system. Within the system it is a functional element, serving the purposes of the system rather than its own inner logic. At the same time, it provides an objective formal conceptualization and description of the system as a whole, or of any part of it. The pro-

positions advanced in this study, with reference to specific military systems in history, are actual or potential ingredients of military doctrine.

Two kinds of military doctrine can be discerned: first, that concerned with the use of combat power, the ends to which it is applied, and the methods of so applying it; and second, that concerned with the control of combat power. "Utilization doctrine" is related to the external projection of combat power--its functioning in an environment; "control doctrine" is related to the internal organization and regulation of combat power, with a view, of course, to its effective use. This study is concerned with both kinds of doctrine, but in different ways. In analyzing the internal elements of control systems, as will be presently shown, the study notes the role of doctrine--both utilization and control--as an internal functional element of these systems. At the same time, as indicated earlier, this study explores, in a preliminary and tentative way, the hypothesis that an intensive but selective examination of command and control in history may provide a solid basis for developing doctrine conducive to effective control of modern weapon systems. In short, its basic concern is control doctrine.

"Control" has been defined as

the process whereby a commander effectively directs military forces so that they are fully responsive to his will. Control depends primarily upon adequate means or measures whereby a commander assures the cooperative and coordinated efforts of his subordinates in carrying out his command assignments; it includes the organization of his force for combat, the assignment of tasks to subordinates, the designation of objectives, and the authoritative direction necessary to accomplish the mission.³

It should be noted that the term "control" is used here in three senses which are logically distinct: the capability of controlling military forces and operations; the exercise of that capability; and the instrumentalities whereby the capability is exercised. Convenience justifies this usage but, in accepting it, there must be consistency in matching the scope of "control-as-means" with that of "control-as-capability". That is to say, control should be construed in the former sense, to include not merely administrative systems, processes, tools, techniques, facilities, and the like, but also other less tangible "means" by which control is effected or limited. Unquestionably training and doctrine are extremely important in ensuring compliance with the letter and spirit of directives. Discipline, esprit de corps, established organizational structure, and familiar operating processes all combine to create the internal coherence and stability that facilitate control. The personality and style of the commander are

significant features in any control system. So, too, is the effectiveness of subordinate commanders in executing orders and responding intelligently to new situations. Beyond all these is the vague but powerful force of habit and attitude, rooted not in training and doctrine alone, but also in sources perhaps outside the military environment altogether. In short, consideration should be given to the totality of means, instruments, and influences that combine to make up a control system which gives a commander the capability of translating his will into effective action.

Elements of a Control System

In the light of the foregoing discussion, for purposes of the present analysis, the elements of a military control system might be categorized under six major headings as follows:

1. Structure: the organization of forces available to the commander.
2. Operating systems: for tactics, administration, and training.
3. Linkage: communications, staff relationships, liaison, and intelligence.
4. Command (including the chain of political as well as military authority):
 - a. Normal, "chain-of-command" direction by superior commanders and higher political authority.
 - b. Extraordinary intervention, by superior political or military echelons of authority, which "short-circuits" the normal chain of command (e.g., deputies on mission in the French Revolutionary armies; Soviet political commissars; presidential invocation of commander in chief powers; Congressional intervention; or intervention by a military commander in the operational sphere of a subordinate judged in an emergency to be inadequate).
5. Personality of commander (to include style, character, and idiosyncracies):
 - a. The specific commander from whose vantage point a given situation is viewed.
 - b. Subordinate commanders.
6. Internal operating atmosphere: troop morale (esprit de corps), discipline, habits, and attitudes.

The underlying concept in the above scheme of analysis is one of a system, or network, in which command decisions are made and transmitted

to the elements which execute them. As a "system", it is to some degree impersonal (elements 1, 2, 3, and 4), but in any given control system, at all echelons (elements 5 and 6), human factors exert a strong, sometimes dominant, influence. It will be readily apparent that the elements are not sharply distinct. Most obviously, "linkage" (element 3) can be considered as one of the internal systems or subsystems under -- "operating systems" (element 2), but it is so vital to command and control that it merits independent consideration. Internal systems might also be considered to include both structure and command, but the distinctions serve a useful purpose nevertheless. By the same token, "operating systems" (element 2) might be divided into several separate components--e.g., administration-operations-training or, under a different schema, policy-doctrine-procedures. There is no clearly defined line dividing the system as a whole from elements outside it. At the top, it blends into elements of higher authority not normally part of the system and, at the bottom, into the "objects" of control (i.e., the forces-weapon systems which execute commands).

The present scheme of analysis also includes, as integral to control systems, the equipment, facilities, and other material means that directly serve the functions of command and control. Weapons themselves may intrude as an element of the system, if used to perform or assist in performing these functions (e.g., military aircraft or armored vehicles used in communications, or even the officer's pistol used to compel the obedience of a soldier). In general, however, technology belongs primarily to the environment in which control systems function, rather than to the systems themselves.

Control and Decision-Making

Decision is implicit in command, and command, as indicated before, is integral to a control system (hence, "command and control"). A useful, though not universally accepted distinction, may be made between "decision" and "decision-making". The latter, in an institutional context, is widely recognized as something far more complex than an individual, intellectual act of deciding what to do (in a "moment of decision")--although to the psychologist this act in itself is complex. Military decision-making is a highly institutionalized, collective process, which includes the gathering of relevant information; the analysis of the situation; determination of available alternative courses of action and the probable consequences of each; submission of formal recommendations by staff and subordinate commanders; and, finally, the decision itself--the commander's choice of action. Sometimes the decision-making process is construed to extend even further, through the issuance of orders or directives and their transmission to subordinates.⁴

"Command and control" thus considers of decision-making, the process just described, plus the control processes by which the decision, the commander's instantaneous act-of-choosing, is implemented. The commander's decision is the key point; the culmination of the decision-making process and the initial impulse in the control process. Decisions by subordinate commanders are the impulse points, booster transformers in the command line.

Military control systems in history may be classified on a scale ranging from highly restrictive systems at one end to highly permissive ones at the other. In the former category, the burden of detailed decision-making is concentrated at high levels of command; in the latter, subordinate commanders exercise wide latitude in interpreting the superior commander's desires; they may implement decisions or ignore or reverse them in response to completely unforeseen developments, or local conditions of the moment, unknown at higher headquarters.

The restrictive or permissive character of a control system inevitably reflects the interaction of the six elements identified earlier. A strong-willed, great leader may, of course, leave for posterity an image of a control system which is little more than a reflection of his personality. But such a commander-dominated system is not necessarily a highly restrictive one. Alexander, Hannibal, Caesar, Genghis Khan, Gustavus, Frederick, and Napoleon were all strong, dominating commanders, but each of them knew how to elicit initiative and resourcefulness in subordinates. And Robert E. Lee, though mild mannered, had a dominant, yet also permissive, relationship to his subordinates. In Lee's case, other elements of his control system must be considered: the brilliance and limitations of his subordinate commanders; sloppy, haphazard organization, administration, and staff work; uncertain communications; virtual absence of formal doctrine or training; baffling combination of high morale (esprit de corps), poor discipline, state and sectional rivalries, intense patriotism—plus the constraints imposed by President Davis, the Confederate Congress, and the state governors. These elements produced a command and control system that was highly permissive and, by objective standards, inefficient. Yet it somehow managed to function adequately and, on occasion, brilliantly.

The Environment of Command and Control

A military control system is more, however, than a product of the interaction of its internal elements. That interaction includes a response to external pressures, influences, and events, to which the system, like all human institutions, must adapt itself. In short, a control system is a creature of an external environment of methodology, conditions, and moving events in response to which it must not merely react, but, in varying measures alter its own shape and character.

Like the control system itself, this environment can be analyzed in a variety of ways. One possible scheme would distinguish four major environmental elements--the military, natural, politico-social environments, and the events occurring in any of these.

a. The military environment.

- (1) Forces (including weapon systems) controlled, or likely to be controlled, by the system.
- (2) Friendly or neutral forces (including weapon systems), associated, or prospectively associated.
- (3) Hostile or prospectively hostile forces (including weapon systems).

Of all the major environmental elements, the military environment exerts perhaps the most direct influence on a control system. As indicated earlier, the forces immediately controlled by the system are in fact intricately enmeshed with it through the character of subordinate commanders, through the state of morale (esprit de corps) and discipline of the troops themselves, and through the internal structure and system that lend cohesiveness and responsiveness to the force as a whole. Forces not directly subject to the control system have parallel systems with which they must work in harmony and close coordination. To a lesser degree, the same is true of associated, friendly, or prospectively friendly forces. Enemy forces and their control systems exert a different, but in some ways more compelling influence, through their power to dictate adaptation as the price of survival.

In considering the military environment, it is important also to recognize the influence on control systems of the technological aspects of that environment -- particularly weapon systems. As primary objects of control, weapons and their supporting systems exercise a decisive influence, through their technical capabilities and limitations, on the character of the control system. This is dramatically evident, of course, in the problem of controlling the responses of modern, automated weaponry. But the problem has existed throughout the history of organized warfare. Battlefield control systems in the 18th Century, for example, were designed around the technical problem of achieving controlled, effective volley fire and weapons, which were extremely limited in range and accuracy, and had to be reloaded in a series of manual operations after each shot. This allowed only a very short period of time for the play of firepower before resort to shock action.

b. The natural environment (weather, climate, terrain, geography, natural resources, avenues of movement, distance).

The influence of natural environment on all aspects of military system is voluminously documented in military history and requires no elaboration here. The most spectacular example of successful adaptation was the superb control system developed by Genghis Khan and his generals in the 13th Century, to achieve rapid movement, coordinated action, and concentration of large cavalry armies in campaigns ranging over immense distances of steppe, desert, and mountains. Unsuccessful adaptation may be illustrated by the failure of the British control system, in the campaigns of 1777, to overcome the handicaps of distance across the Atlantic and in widely separated theaters of operations in North America.

c. The politico-social environment.

- (1) Political: organization, policy, controls over military.
- (2) Social, economic, cultural institutions, and conditions.
- (3) The environment of ideas and attitudes.
- (4) The technological environment.

Of these four subelements of environmental influence, that of technology is the most evident, particularly with regard to its impact on communications. The effect of the railroad and telegraph on 19th-century systems of control is one of the many examples. The problem of devising effective controls for weapon systems is directly related to the larger technological environment of the society which produces these systems. Consider, for example, the close relation between gunpowder weapons, at any time during the past five centuries, and the then-existing state of chemical and metallurgical science.

The other three influences are more indirect and subtle, but, nevertheless, profound. Military control systems have seldom been able to insulate themselves from the play of politics; this is as true today in contemporary France, the Soviet Union, and South Vietnam as it was in the days of Imperial Rome. Military control systems must accommodate themselves to, or else dominate, the political institutions of the society they serve. No less profound, if sometimes less visible, is the influence of the social, economic, and cultural environment on military control systems. Take, for example, the role of a society's economic class structure in shaping the composition of its professional military class. And the impact of ideologies -- particularly new and revolutionary ones -- has created major landmarks in the history of command and control (notably in the emergence of the control systems of the French Revolutionary and Russian armies).

d. The environment of events.

Since events occur in an environment of static conditions and relatively slow-moving developments, and are distinguishable from the

latter only in degree, it is perhaps a semantic refinement to consider events as a separate environmental influence on command and control. Yet the best justification for so categorizing them is the tendency, deeply rooted in human psychology, to regard occurrences which visibly "happen" in a moment, or a definably brief span of time, as something apart from the underlying, largely imperceptible movements in human affairs which are perceived only by dint of intellectual effort. For present purposes, it is sufficient to recall the profound impact upon command and control systems of such events in the military environment as the Battle of Adrianople in A.D. 378 or the Battle of Crecy in 1346, both of which resulted in immediate and relatively sweeping changes in basic military concepts.

Application of Historical Experience to Current Problems

The French military theorist, Ardant du Picq, wrote: "Experience is long and life is short. The experiences of each, therefore, cannot be completed except by those of others."⁵ The study of past campaigns is the most obvious method of filling in the gap between personal experience and the breadth of knowledge needed by commanders and by those whose business it is to anticipate the requirements of future warfare. Military historians do not expect the study of history to produce exact or even closely related parallels to situations that may later have to be faced. Indeed, one of the great dangers of reading military history uncritically is the tendency toward slavish adherence to outworn traditions and methods, summed up in the term "military conservatism". What the historian hopes is that the past will be used as a bedrock of vicarious experience, to be built upon by architects and builders with critical and analytical vision. The case for military history rests, as Brigadier W. G. F. Jackson puts it,

on its value in developing the military judgment of future commanders [and, one might add, other students of war] by stocking, sharpening, and inspiring their minds while, at the same time, giving them a sense of what is practicable in war."

A second major danger in the study of military history lies in its malleability. "History", wrote Carlyle, "is a distillation of rumor."⁷ This problem is amplified by the fact that no historian can hope to cover all aspects of an event, but must choose and distill and, perhaps, oversimplify. It is also unfortunately true that some historians may be more interested in sensationalism, or in proving a personal theory, than in accurate reconstruction of the past.

The danger is particularly acute for those who would seek evolutionary trends or processes through the study of history, for history is so replete with examples of every type of action that it

is always possible to find an appropriate incident to support a particular theory. The only way to avoid this danger is by objective, critical analysis. No historical theory should be accepted at its face value but should be subjected to extensive analysis based on the widest possible scope and depth of study.

It has been seriously asserted, for instance, that nuclear weapons are only a stage in the evolution of weapons and tactics, comparable to the advent of gunpowder and automated weaponry, and that the difference is merely one of degree. Under scrutiny, this assertion proves to be a moot generalization. While not without elementary validity, it is in fact a straw man which impairs the very thesis it is intended to support: the relevance of historical experience to modern military problems. The pragmatic, nonhistorical critic will be quick to point out that nuclear weapons constitute a quantum leap forward in terms of destructiveness within a given unit of time. He can also point out that wholesale unleashing of these weapons would be tantamount to suicide for large portions of the human race--a phenomenon for which history offers no precedent.

These arguments do demolish the straw man, but not necessarily the thesis. Valid comparisons of modern and early weaponry are difficult to make, because the concepts themselves have changed. The modern, tactical, one-kiloton "nuke" is, in the first place, the "cutting edge" of a system comprising an elaborate delivery and support apparatus, served by a large number of personnel, and reaching well back into an army's administrative establishment. Without this supporting apparatus the projectile or the missile would be inoperable. It is doubtful whether any single weapon in earlier ages is quite comparable in this sense."

The weapon "systems" of history were, in fact, families of related weapons, each of which was, at any given point in time, the end product of a complex evolutionary process. Though closely inter-related, these weapons did not develop as homogenous, integrated systems. Gunpowder weapons, which began to dominate warfare in the Western world in the 15th Century, were one such family. They were, however, only a part of the larger complex of weapons and tactics that overthrew the supremacy of mailed cavalry. The ascendancy was gradual. The early gunpowder weapons, using chemical explosives as a propellant for inert (in themselves harmless) projectiles, were for a long time so inaccurate, cumbersome, unreliable, expensive, and dangerous to their users that soldiers were reluctant to adopt them. The bow, in its various forms, was superior to the early infantry firearms in range, accuracy, rapidity of fire, and cheapness. Eventually, two factors proved decisive in displacing the older weapons: the greater energy released by gunpowder, making

infantry firearms superior in killing power and, ultimately, in range; and of perhaps less significance, the greater ease and rapidity with which ignorant soldiery could be taught to use firearms as opposed, for instance, to the long training needed to develop a first-rate archer. Gunpowder artillery weapons had also proved their superiority in power – though not until later in accuracy or range – to the traditional, mechanically powered siege and field artillery inherited from classical and medieval times.

Automated weapons made a more dramatic impact on warfare around the turn of the 19th and 20th Centuries. In a modern sense, these, too, comprised a weapons family¹⁰ rather than a system; including both single-operator and crew-operated machine guns and quick-firing artillery. In the latter instance, the element of automation was subsidiary in importance to the introduction of high explosives.

The perfection of the high explosive shell, namely in the gradual improvement in the power of chemical explosives, culminated in one of the major developments in the gunpowder era. The explosives were used for two distinct purposes: as propellants (already mentioned) and as destructive energy released directly on the target. The development of chemical propellants reached a plateau in the late 19th Century with the rifled musket and field piece which, in terms of accuracy and range, have improved very little. The effectiveness of explosive-on-target weapons, on the other hand, originating with the earliest crude bombs and shells fired from smoothbore cannon, have steadily continued to develop. Atomic and nuclear weapons, even though representing a quantum leap in the single respect of released energy, belong to this line of development. The combination, in the early 20th Century, of many elements and converging lines of development – accuracy and range through rifling and chemical propellants; automation (at some sacrifice of accuracy); high-explosive destructiveness; and, finally, additional range through aircraft, rockets, and missiles (at heavy cost in accuracy) – had an impact on the battlefield that serves, by comparison, to place the atomic-nuclear revolution in a more readily understood perspective.

In one sense, seldom noted, nuclear weapons have made a clean break with history. In the past, the classic method of amassing firepower was to multiply the number of soldiers, or of weapons, each of which contributed an increment to the total. Now, the explosive energy of nuclear weapons is so great that an increment of one represents an increase in firepower unrelated, in any real sense, to the number of personnel comprised in its supporting system. Firepower has increased to such a degree that the historical concept of a man-weapon ratio has itself become virtually meaningless. Indeed, a modern division can unleash a volume of firepower so immense, by comparison with that of a force of the same size in any earlier period, that the difference can properly be regarded as one of kind rather than degree.

There is a question, however, whether quantity of firepower can be equated to destructiveness. The bloodiest battles of history were fought, in the main, with primitive weapons. And those of the 18th Century, the age par excellence of the inaccurate, slow-firing, short-range, smoothbore firearm, were among the bloodiest. At Malplaquet (1709), the victors lost 33 per cent of their effectives; at Zorndorf (1758), the Russians, who were defeated, lost 50 per cent as opposed to the 38 per cent loss of the victorious Prussians; and in the year following, at Kunersdorf, the defeated Prussians lost 48 per cent of troops committed. Casualties on this scale were rarely equalled in later periods, including the great wars of the 20th Century, when firepower was immensely greater.

Today a force armed with nuclear weapons could presumably obliterate an enemy, almost regardless of number, if the latter was obligingly massed on a level field without cover and within range. Of course such a situation would not occur today. But on the 18th-century battlefields things like this did happen, although slaughter was usually brought to an end by the disinclination of one side or the other to continue.

In general, firepower has been destructive (of human life, at least) in the measure that men have exposed themselves to it. Over the greater span of history, the natural tendency of men under fire to seek cover has been counteracted by tactics of mass or line designed to achieve disciplined, coordinated defense against shock attack and by massed counterfire. Only by mid-19th Century, when improved weapons rendered firepower so lethal that men could no longer stand under it, was the mass or serried line abandoned for the protection which could be obtained by using terrain. The factors that have made warfare so destructive in the 20th Century—duration and intensity of campaigning, mobilization of men and materiel on an unprecedented scale, attacks on civilian populations and structures—are largely unrelated to the growth of battlefield firepower.

Destructiveness is a function of two factors—released energy and accuracy. Accuracy is the measure of the efficient use of explosive energy. Nuclear weapons have enormously enlarged the former, but at heavy cost to the latter. This reflects one of the continuities of history. During most of the age of chemical explosives, accuracy rose along with power, both factors jumping upward in the mid-19th Century with the advent of rifled weapons, improved propellants, and the metallic cartridge.

With the advent of nuclear weapons, while the factor of released energy—explosive power--leaped upward, together with range, accuracy declined sharply. Only recently has this decline in the accuracy curve leveled off and begun to rise again, coincident with the growth of low-yield nuclear weapons.

There remains, however, the fact that the use of explosive power directly on target may represent a grossly inefficient use of destructive power, in terms both of dissipation of energy in the atmosphere or on inert, basically indestructible terra firma and in terms of excessive destruction, i.e., vaporizing or liquefying human and material targets which, for military purposes, it would suffice merely to kill or disrupt.H

This quality of "overkill" in nuclear weapons, while inherent in the whole development of explosive-on-target weapons, has reached the point of halting, or at least suspending, another historical continuity--the search for constantly greater explosive energy. There are indications that the major problem in nuclear weapons development today has become one of packaging smaller, not larger, concentrations of power in the individual unit delivered on target, in order to avoid a degree of destruction that, far from serving military purposes, may run counter to them.

Nuclear firepower, despite its waste of explosive energy, has added a theoretical dimension of destructiveness to warfare primarily in the strategic sphere. Almost two decades after Hiroshima, cities appear to be almost wholly defenseless against nuclear attack. But it is important to remember that the increase in destructive power is true in a special and limited sense--the capability for destruction within a given unit of time. Man has always possessed the power to kill and destroy; and this is an absolute power. On the whole, ancient cities were sacked and obliterated more thoroughly than those in the recent past: Nineveh, Babylon, Tyre, and Carthage, for instance. And during the closing months of World War II, the fire storms unleashed by American bombing raids on Tokyo (rather than the damage caused by the bombs themselves) inflicted more devastation than did the atomic bombs dropped on Hiroshima and Nagasaki.

The defenseless city is not a new phenomenon in history. The best analogy to modern weapon systems (nuclear-tipped, long-range missiles or nuclear-armed, strategic bombers with their supporting systems) is not to be found in individual weapons of the past, but in the effective weapon system of the 13th-century Mongol horde, which could wipe out segments of civilization in weeks and months. Walled cities could not repel these forces which employed amazing speed, mobility, engineering skill, and striking power. For longer than we have lived with the nuclear weapon, a large part of the civilized world could find no defense against the Mongols other than distance. Today, even distance no longer avails. But overnight, a new breakthrough (in a technology which has made the very word "breakthrough" commonplace during the past two decades) could reverse this situation.

Precisely what does it mean to say that cities are defenseless against nuclear attack? In essence, it means that two of the historical means of defense--active defense through the repulse and defeat of the attacking weapon or force by one of superior strength (or "shooting down a bullet with a bullet") and passive defense through manned fortifications--are useless. There remains, however, a third means of defense which has equally valid historical credentials--deterrence[^]. A would-be attacker, strong enough to overcome active and passive defenses may be deterred by the threat of penalties which he is unwilling to accept. History provides a long list of such penalties--execution of hostages held by defenders, loss of territory which would be left unprotected by the movement of forces incident to carrying out an attack, the antagonism of third parties whose vital interests would be endangered, the outrage of public opinion, or simply the prospect of incurring prohibitively heavy casualties in the course of attack. All these historical "sanctions" can still be invoked to deter a nuclear strike on cities, the most effective, perhaps, being the "hostage" status of the would-be attacker's own equally defenseless cities.

It is beyond the scope of this paper to measure the extent to which the deterrent policies of the major nuclear powers have made unlikely the use of both strategic and tactical nuclear weapons. Suffice to say, the voluminous literature on this subject has explored in exhaustive detail both the nature and effectiveness of deterrent retaliatory capabilities and the still-unsolved problems of waging limited war in a nuclear environment. While the subject remains highly controversial, the prospect of a limited nuclear conflict appears, on the whole, remote.¹² To this extent, the traditional concepts of the utility of military history will probably continue to have relevance for the foreseeable future.

Even if nuclear weapons are not used, however, the spectre of the atom still will hover over all actions and relationships between nations, so that military and politico-military affairs will constitute a vast poker game in which the stakes are national survival. Thus--as has been frequently noted in recent years--the responsibilities devolving upon those responsible for the employment of military force are heavier than ever before. If the responsibilities and consequences are greater, then it follows that the experiential background needed by those in responsible positions is also infinitely greater. Personal experience, awareness of history, and theoretical exercise are the three basic means by which this background can be gained and, of these three, history is the least limited and, in comparison with theory, infinitely closer to reality. It may, indeed, be found that no historical precedent

can provide guidance for some of the difficult decisions facing commanders in chief in the future—but they cannot be certain of this and cannot wisely cast loose from history unless they fully understand the range, scope, and limitations of possible historical precedents.

Both tactically and strategically, as we have seen, nuclear weapons can be readily placed in historical perspective, without minimizing the absolute or relative destructiveness of such weapons—which is unquestionably cataclysmic. Furthermore, despite the discontinuity which this awful destructiveness creates in terms of actual battlefield example, we must agree with Brigadier Jackson that

nuclear weapons have not destroyed the positive uses of military history because these weapons are restricted to a small and, we hope, unlikely segment of the spectrum of war. On the contrary, the risks inherent in the nuclear era demand from future commanders a higher standard of military judgment.¹³

Judicious use of military history can provide a source of input to expand the practicality and scope of judgment.

Notes

1. C. W. C. Oman, The Art of War in the Middle Ages (Ithaca, New York, 1953), chap, iii; J. F. C. Fuller, Lectures on FSR-II (London, 1931) and Lectures on FSR-III (London, 1932).

2. See Appendix A; Glossary.

3. Ibid.; Note also that, while combat is the principal function of military forces, they also have other missions.

4. Ibid.; Note definitions of "command and control" and decision-making".

5. Battle Studies, (trans.)(Military Services Publishing Co., 1947), p. 8; the first sentence, of course, is merely a rephrasing of the aphorism first attributed to Hippocrates, but repeated by Horace, Chaucer, and Longfellow, among others.

6. "Forward-Looking Retrospect", Journal of the Royal United Services Institution, (Nov., 1962).

7. Thomas Carlyle, History of the French Revolution, VII, chap. v.

8. It may be pertinent to recall, however, the immense bombard used by the Turks in the siege of Constantinople in 1453--not in terms of its destructive power, which was not remarkable in absolute terms (though remarkable for the times) but of the size and elaborateness of the train of engineers, technicians, transport, and laborers required to serve it.

9. This is the reason why the several types of bows in ancient, medieval, and modern times tended to be products of regional or national specialization: e.g., the longbow in Wales, later adopted by England; the powerful Turkish horn bow; the crossbow (to some degree) in Genoa; the various short bows developed by the horse archers of antiquity in the Near and Middle East.

10. Strictly speaking, a sub-family within the gunpowder-weapons family.

11. A point emphasized by the multiplicity of artillery weapons as developed up to the present time; emphasized by the homely adage that one doesn't use an elephant gun to kill a fly.

12. We cannot ignore the fact, however, that both sides have the means to initiate such a war; what is likely to inhibit them doubt whether limited nuclear war can be fought in any logical, coherent sense.

13. Op. cit.

Part Two

CONTROL AND DECISION-MAKING IN WARFARE

Introduction

The general purpose of Part One of this report was to show the usefulness and relevance of historical experience to modern military problems in general and to command and control in particular. Part Two scans the spectrum of command and control as exercised through the centuries: its evolution and its variations, illustrated by human actions and reactions under a diversity of circumstances.

After briefly noting the relationship of military control systems to the societies which they serve, we will discuss the way in which this relationship has been demonstrated over the course of history. The principal portion of this discussion concerns itself with control systems in general, but concentrates on the exercise of political and military control in land warfare. The last two sections deal with specialized aspects of control systems in naval and air warfare.

The Enclosure to this part of the report contains a list of some historical examples (most of which have been discussed directly or indirectly in the text) which might be suitable subjects for more intensive investigation in depth as historical case studies relevant to modern problems of command and control. These examples are roughly grouped into four categories: (1) those in which the command and control issues were primarily political; (2) those primarily involved in land warfare; (3) those primarily involved in naval warfare; and (4) those primarily involved in air warfare.

Control Systems and the Evolution of Societies

Of all military institutions, command and control systems (which have long existed, even if only recently classified as such) are perhaps most resistant to rapid and radical change. They tend to evolve gradually, adapting themselves reluctantly to the challenge of new weapons and tactics and to changes in the political and social environment. Even cataclysmic events, which may destroy armies and overturn thrones, do not alter overnight the settled ways of thinking and doing which constitute the tough inner fabric of systems in general, including those of military command and control.

Control systems must compete violently with opposing systems in order to survive; for each victor there must be a loser. History records occasions when control systems were destroyed, along with other social institutions, as a result of military defeat and conquest. Presumably this was one of the unnoticed consequences of the fall of Sumer, Assyria, and other great empires of ancient times. A more vivid example, in our own day, was the virtual destruction of the German Army General Staff system during World War II, with Hitler himself delivering the coup de grace in the blood bath which followed the abortive conspiracy of July 1944.

Command and control systems, by their nature, however, have roots in the societies they serve. War and conquest may obliterate all that shows above ground but, if the society itself survives, the roots are likely to sprout new foliage that strongly resembles the old. It is far too soon to conclude, for example, that the new military institutions now emerging in Germany and Japan, following the apparent extinction of the old, will assume forms wholly different from those that flourished before the war.

The processes of institutional diffusion are more pervasive here than in other areas of cultural interaction. The very pressure of competition between hostile military systems creates a common environment in which mutual imitation becomes a law of survival. The transfer of characteristics is, of course, primarily from stronger, more successful systems to weaker ones; but the reverse process also operates. Eventually major differences among systems tend to disappear. The whole process of mutual imitation counteracts--and in turn is modified by--the opposing tendency of national or cultural peculiarities to perpetuate themselves. Like other social institutions, military control systems often take form, in their early stages of development, in relatively isolated national environments, sheltered from powerful external pressures. But once fully formed they must, through the sheer necessity of performing their natural functions (i.e., in war or preparation for war), plunge forthwith into competitive struggle with systems of adjoining societies. In the course of the struggle strong systems become dominant, imposing their essential features on the weak, but absorbing in the process some of the useful features of the latter.

The Exercise of Political and Military Control in Land Warfare

The Origins of System: Macedon and the Ancient World

The pattern of development is illustrated by the Macedonian command and control system, the instrument of Alexander's conquests

and the first of the fully documented great military systems--the foundation on which all later systems in the Western world were built. Carefully forged by Alexander's father, Philip, in the mid-4th Century B.C., it grew to maturity on the fringes of Greek society, shielded from major tests of strength against either the dominant Greek military systems--Sparta and Thebes--or those of the moribund Persian empire to the east. Naturally it built upon already existing foundations: the traditional Greek phalangial system, with supporting arms, which had triumphed against the Persians in the preceding century; and the brilliant innovations of the Thebans, which had been dramatically successful against the dominant Spartan system in the Battle of Leuctra in 371 B.C. But it was a fully mature system, tempered in a long series of "safe" border wars against weaker opponents and refined by methodical organization and training, which at Chaeronea (338 B.C.)--a battle of which we know little except that it occurred--decisively crushed the phalangial armies of Greece and inaugurated its career of conquest.

This Macedonian command and control system contained, in essence, the basic principles on which all succeeding systems have been based. These were: a general plan of battle, with concrete objectives specified for subordinate elements; some degree of coordination among the combat arms; and the retention of a mobile reserve, to be committed only at the critical point and time to influence the result. The purely phalangial system which it superseded, basically rigid and suited primarily to defense in a fixed position, had no such flexibility.

For two centuries or more the Macedonian system was widely imitated and dominated land warfare in the ancient Near East; it gradually lost vitality in the process. At Pydna (168 B.C.), it succumbed to the Roman legionary system which too evolved slowly and was protected in its formative years from dangerous external threats. Long before Pydna the Romans had overcome, by a narrow margin, a formidable challenge in the wars against Carthage whose military power was derived primarily from its wealth and the genius of its great commander, Hannibal, rather than from its military or social institutions, inferior, on the whole, to those of Rome. Hannibal's techniques of control, at the peak of his success, differed little from the model created by Alexander. The legionary system, on the other hand, was supreme for the ensuing five centuries and contributed significant new features of strength in the institutional areas of command and control--formal doctrine and training, tactical organization, linkage, chain of command, and underlying social and political cohesiveness--which made it astonishingly immune to the shortcomings of mediocre commanders.

Primitive and Sophisticated Control Systems

The interacting processes of competitive imitation and national or cultural differentiation described above can be seen in operation throughout the centuries of subsequent development. They can be seen, in our own times, in the history of the German Army General Staff system which, with national variations, was imitated by all the military powers of the early 20th Century and, despite its formal extinction at the end of World War II, remains a powerful influence today.¹ Each of the great military systems of history has produced its own variants of the systemic elements of control.² But over the whole immense span of time from the 4th Century B.C. to the 19th Century A.D., the underlying characteristics of military control in land warfare have remained remarkably constant.

The most obvious distinction is between relatively primitive and relatively sophisticated systems. In the former (normally a feature of societies still in an early stage of development--the Goths, the Franks, the Vandals, the Northmen, the Arabs of the initial Islamic conquests, and the Seljuk Turks), command and control--characteristically permissive and largely ineffective--merits in general only passing mention. But a few, startling exceptions to the usual association of primitive control systems with young societies should be noted. The Ottoman Turks, for instance, developed a highly refined, effective, centralized command and control system which, in its day, was one of the best in the world. In the 13th Century the Mongol system was even more formidable--perhaps the most formidable in history. Conversely, the feudal society of medieval Europe, paradoxically founded on war as its raison d 'etre, which dedicated its dominant elite to the pursuit of war and which attained high levels of sophistication in most spheres of human development, never achieved an effective system of military control, even in the great religious military orders.³ Under firm leadership, on rare occasions, medieval armies operated with discipline and tight control (as Richard I showed at Arsuf and Jaffa, 1191). But the more typical performance brought disaster to the massed chivalry of central and eastern Europe, including large contingents from France at the hands of Mongol cavalry armies (at Liegnitz and the Sajo River, 1241). This was the triumph of a truly sophisticated, finely wrought control system over one that remained crude and unfinished, even after many centuries of development.

Until the 19th Century, the more sophisticated military control systems of history were more restrictive than permissive in character; the single commander was customary. On occasion, however, command was exercised by two or more coordinate commanders simultaneously or alternately (e.g., in different sectors of the battlefield), or through a "council of war", which imposed its direction on one or more operational commanders. These occasions were comparatively rare for, even when the principle of divided battlefield command has been institutionalized, it has often been evaded in practice. Under single

commanders, control systems tended to be restrictive rather than permissive, by virtue of the confined arena in which battles were fought and owing, in turn, to the limitations of weapons and communications. Napoleon's control of the course of battle at Borodino or Waterloo (1815) was scarcely greater, or less, than that of Marlborough at Blenheim, a century before, or that of Alexander at Arbela, twenty-one centuries earlier. Each commander, on each occasion, could see most of the battlefield. Probably the major advance in command and control, over the entire span of time, had been the personal withdrawal of the commander from combat in order to direct maneuver. This increased the flexibility with which commanders could manipulate reserves, shift committed elements from one sector to another, and otherwise employ maneuver after the battle was joined. Well into the 19th Century, the Napoleonic concept of the commander's coup d 'oeil (as the essence of military genius and the controlling factor on the field of battle) provided the traditional image of command and control. Yet the coup d 'oeil was an illusion. Both it and the commander's battle plan remained (and still remain) largely at the mercy of the accidents of battle--sudden panic, unexpected resistance by troops who "should" have yielded, but did not, the intercepted message, the misunderstood order, or the unnoticed terrain obstacle.⁶

In viewing the long development of these systems, no "law of progress" is discernible. Control systems emerge and evolve as part of the institutional fabric of a society. As a society decays, so does its military control system. There is, of course, a recurrent progression from simple to more complex, sophisticated forms of military control, but this kind of development cannot be equated necessarily with successful adaptation to the competitive environment. History is strewn with the ruins of sophisticated control systems which collapsed before rudimentary ones: the Roman legionary system, with seven centuries of growth and glory behind it, fell at Adrianople (A.D. 378) before the onslaught of ill-organized Gothic horsemen; seven centuries later, the professional turmas of Byzantium were crushed at Manzikert (A.D. 1071) by the Seljuk Turks, semibarbaric horse-archers originating in the steppes. In neither case can it be assumed that the system was more at fault than the accidents of circumstances and (at least at Adrianople) poor generalship. Whatever the direct causes, these catastrophies were reinforced by the indirect effects of underlying political and social deterioration which inhibited subsequent recovery.

The Modern Revolution in Warfare

In the 19th Century all modes of warfare were profoundly transformed by the French and Industrial Revolutions. From the forces

released in Europe by these two interacting revolutions the citizen soldier emerged: fervidly patriotic, relatively literate (and thus susceptible to nationalistic propaganda), suspicious of his superiors, averse to military discipline, often mutinous, capable of vast endurance and prodigies of valor, but also fickle and easily panicked. He was armed with weapons of growing precision, accuracy, and destructiveness. Command and control systems had to be adapted to the fundamental changes in the soldier and his weapons and to the increasingly complex supporting linkage mechanisms. Revolution and war intensified nationalistic feeling everywhere, giving governments enormous powers over war-making resources, including the power to call forth young and middle-aged men by the hundreds of thousands. This levee en masse, soon institutionalized in national systems of conscription, became an accepted instrument of the new way of war.

In the realm of technology, the 19th Century brought about spectacular, revolutionary new weapons which, from the middle of the century on, immensely increased the volume and effectiveness of firepower. These innovations scattered and drove to cover the dense masses of troops that for centuries had crowded into relatively small battlefields. The army commander was left far out of sight or sound of most of his troops, and the individual unit or sector commander had in increasing degree to make his own decisions.

Yet this trend toward permissive control systems and decentralized decision-making that resulted from the massive increase in firepower did not in itself imply a weakening of command and control. Conditions of warfare placed new demands on doctrine as well as on the initiative and resourcefulness of subordinate commanders and on the efficiency of military administration. The situation in which the battalion commander in the battles of 1863, 1866, or 1870 found himself when dealing with the enemy immediately confronting him, was essentially the same as that faced by Alexander, Caesar, Gustavus Adolphus, and others who had massed whole armies on single battlefields and maneuvered them by voice, trumpet, standard, and courier. With few exceptions, only the messenger remained to link the lonely battalion commander with other commanders to his right, or left, or with the remote general whose strategic design might succeed or fail through his actions. This was a school that bred commanders, or broke them, in short order. And it was supplemented by a growing emphasis on more formal schooling in the classroom and in field maneuvers and on the formalization of routine administration. The Prussian Army General Staff, imitated by all major powers in the late 19th and early 20th Centuries, became the symbol of a new kind of military professionalism, built upon systematic education and technical training, planned career development, carefully formulated doctrine, highly developed staff and administrative procedures, and, perhaps most important, a strict code of professional conduct and service. All this provided the ingredients for a system of command and control designed to operate efficiently and execute the purposes of the high command even after communications had been blotted out in the roar of battle.

Moreover, even while the growth of firepower was imperiling higher commanders' control of maneuver on the battlefield, the new technologies of linkage—the telegraph, the railroad, the steamboat--were enhancing the capability for effective and continuous control over strategic maneuver and the conduct of far-flung campaigns. The telegraph, alone, gave governments an unprecedented degree of control over distant commanders, curtailing their power of independent decision. In the process also, through the new medium of the popular press and field correspondents, the telegraph not only brought military operations under the scrutiny of an insatiably curious, emotional, and ill-informed public, but opened wide gaps in security curtains.

On the eve of the First World War, linkage technology verged on a breakthrough, even in the realm of battlefield communications. By means of the telephone, high commanders could hope to maintain contact with front-line units, at least in fairly static situations. Motor vehicle transport, while not yet fully adapted to large-scale troop and supply movement, offered commanders and staff officers a means of rapidly moving about the fringes of the battlefield in speedy staff cars. Radio communication, still in its infancy, was introduced. By and large, on the eve of the great war, military command and control systems had attained a degree of sophistication, and an apparent capacity to use effectively the new instruments of warfare, which competent observers found entirely reassuring. The holocaust of 1914-1918 proved them to be wrong.¹

The breakdown in command and control in World War I was due not alone to spectacular advances in weaponry; it was caused by the larger economic revolution which swept both Europe and the United States during the 19th Century. A vast accumulated potential for mass production and movement of war materiel, implemented by a new form of levee en masse (with women replacing men in factory and on farm) not only freed a larger porportion of manpower for combat but also produced materiel in unprecedented quantity. The "nation in arms" was replaced by the "nation at war". This flood of weaponry, other materiel, and manpower literally choked existing command and control systems on the Western Front.

Roads, wire, and such innovations as small-gauge railroads for hand haulage on the battlefield itself, were obliterated by massed artillery. Unit commanders had little scope for imaginative action in the prison of interlocking trench systems and the heavily manned, continuous, sealed front which the Western theater became by 1915. Until the Germans introduced their Hutier tactics there (1918), there seemed no alternative to frontal attack by massed infantry behind a rolling barrage of artillery; and even this invariably bogged down, through exhaustion of men or supplies, after an advance of a few miles or yards. The new tactics provided no answer to the

problem of continuously moving up—and behind the advancing attack—the immense quantities of materiel needed to sustain momentum. Finally, and extremely significant, the sheer erosion of initiative and hope among men at all levels of authority was the result of sustained exposure to front-line conditions.

In other theaters of the war, however, where geography and terrain permitted tactical and strategic mobility, the sophisticated command and control systems developed by 1914 worked adequately. Indeed, the consistently superior performance of the Germans, who were almost always in inferior numbers on the Eastern and Italian fronts, is difficult to explain in terms of materiel superiority alone, and strongly suggests a high degree of qualitative superiority in the sphere of command and control.

From the end of the First World War to the end of the Second, the evolution of command and control was shaped primarily by two parallel developments. On one hand, new weaponry and improved transport permitted a revival of tactical mobility and sustained forward movement for considerable distances (most dramatically displayed in the North African desert campaigns of 1940-1942). On the other hand, despite the new mobility, developments in communications technology restored to higher commanders the capability of closely controlling the actions of subordinates. Since, however, the subordinate commander almost invariably had intimate knowledge of the situation in his own sector which was denied to his superior, the capability of frequent and even continuous communication between the two often permitted a dialogue at each stage of an operation or at each point at which a new decision was required. From this dialogue, ideally, emerged a synthesis of the two viewpoints: permitting a decision by the higher commander which blended the information and recommendations of the subordinate with his own knowledge of the larger situation and the broad objectives of the operation. The fairly frequent occurrence of this kind of situation in World War II pointed to the need for resourcefulness and self-reliance on the part of subordinate commanders. Combat operations were too fast moving, and communications breakdowns too common, to permit a reversal of the general trend toward permissive and flexible control systems that had begun a century or more earlier. But the merging of the commander's broad view with his subordinate's local view of the battlefield situation made possible a kind of technological balance among the means of fire, movement, and communication, presenting an entirely new environment for decision-making.

Political Authority and Military Control

The warrior king—combining in his person supreme political and military authority—who personally led his troops in battle, was one

of the oldest and most continuous players on the stage of military history. But in 1815, with the passing of Napoleon, the last of the "great captains" and warrior kings, the institution became extinct for all practical purposes. The tradition lives on, symbolically, in heads of state who, in virtually all countries, whether their authority is real or nominal, are vested with formal command of the armed forces. This is true in the United States, which has no royal tradition; in France, a presidential republic with an ancient tradition of monarchy; and in present-day Great Britain, a constitutional monarchy where real sovereignty resides in the legislature. It was true in prewar Japan, a constitutional monarchy where the military advisers of the Emperor held the reins of power; in the Second German Reich of the Hohenzollerns, a traditional constitutional monarchy with power centered in the crown; and in Hitler's Third Reich, a naked dictatorship.

Under warrior kings, such as Alexander of Macedon, Charles XII of Sweden, and Napoleon Bonaparte, acute problems of defining the role of political authority in the military command structure did not arise. But in the 18th Century, especially in France and part of Germany, royal favor frequently placed titled incompetents in posts of high command, where their amateurish meddling jeopardized the conduct of military operations by the professionals. In effect, the political authority of the state was projected downward into the regular command structure, where its actual role tended to be capricious and irregular. The ensuing difficulties stimulated the growth of rudimentary military staff systems in this period, particularly the emergence of the institution of the "chief of staff"--called also maitre des logis or general quartier meister--who carried on the real work of planning campaigns and coordinating military administration behind the facade of the nominal royal high command. It is significant that the example of Napoleon, who was a genuine warrior king, actually set back the institutional development of European command and control systems until the emergence of the Prussian General Staff in the mid-19th Century.

The Prussian General Staff emerged primarily in response to the growing complexity of war and military administration and resulted in increasingly strict delimitation of the political and military spheres of authority. The whole thrust of new military professionalism, as expounded by its apostle Clausewitz, emphasized the subordination of the military to the political authority as a pure instrument of state policy rather than a power determining its own ends. The Prussian philosopher of war wrote:

The subordination of the political point of view to the military would be unreasonable, for policy has created the war; policy is the intelligent faculty, war only the instrument, and not the reverse. The subordination of the military point of view to the political is, therefore, the only thing which is possible.

This meant, in theory, that the political authorities of a state would define policy, including the decision for or against war and if the former, the broad objectives to be sought in conflict. It was the responsibility of the professional military leaders to advise their political superiors as to the feasibility of the objectives prescribed and then, whether or not their advice was accepted to try to achieve them. The political authorities, for their part, had the obligation to provide the means required by the military to carry out approved policies, including authority commensurate with responsibility.

By the end of the 19th Century, this theory corresponded with the actual division of labor between the two spheres of political and military authority in most nations. The difficulty lay in delimiting exactly, in concrete situations, where the line should be drawn between the two. In other words, assuming that supreme political authority was exercised by a civilian executive (whether absolute or responsible in turn to an elected legislature), who was ultimately responsible for the conduct of war, the question arose whether the conduct of the war, at the next lower level of authority, should rest with the professional military leaders or should remain under the supervision of the chief executive, either directly or through intermediate civilian, political officials. The American President, Polk during the Mexican War, took a direct part in planning and coordinating strategy, and both Presidents, Lincoln and Davis, in the American Civil War, participated actively in the strategic direction of military operations. Legislative intervention at this level of military control occurred more rarely, but the role of the Civil War Congressional Committee on the Conduct of the War vividly illustrates the problem.

Nevertheless, by World War I, governments generally accepted the proposition that the immediate "military" direction of war should be left to the professionals. In the American system this acceptance was institutionalized in the sharp organizational division of responsibility. The military establishment divided authority between politically appointed civilian secretaries, who controlled the expenditure of money for military purposes and supervised the technical and administrative bureaus (headed by military officers), and the professional military chiefs of the armed services who, in "military" matters (i.e., strategy, operations, training), reported directly to the President, although they remained subordinate to the civilian secretaries in "administrative" and "technical" matters. This arrangement theoretically ensured that no civilian judgments or attitudes would be interposed between the top military leaders and the civilian commander in chief, to whom they were directly responsible.

In prewar Germany, an authoritarian government with a strong militarist tradition, the sphere of professional military authority was somewhat broader and, within the military establishment, civilian influence was weak. To an even greater extent than in the United States, the basic Clausewitzian principle prevailed--that the actual conduct of war, below the level of policy-making, was a professional military matter. The implications of this view, and the evidence of its acceptance, were exemplified in a dramatic incident on August 1, 1914. At that time Emperor Wilhelm II was informed by the younger Moltke, his Chief of Staff, that it would not be possible to re-deploy against Russia the German armies which were already massing in the opposite direction for an invasion of France. The shift seemed desirable on the political grounds that this would influence England not to intervene on the side of France. The significance of this incident was not the Emperor's acceptance of this verdict but the fact that, under the established division of authority, military leaders had been given free rein in military plans and arrangements which, by circumscribing the political options, actually dictated policy at the highest level. (That this was totally inconsistent with the military philosophies of Clausewitz seems never to have occurred to the Germans, his most ardent disciples.)

Most other governments also embarked upon the First World War with the military in full control of the "military" aspects of the war effort, as variously defined. In the United States, President Wilson, rejecting the traditions of Polk, Lincoln, and Davis, carried the principle to an extreme. In Germany, under the pressure of defeat and growing hopelessness, the already dominant military eventually took over de facto control of the government.¹⁰ In other countries, however, the general paralysis of strategic control in the high commands, and the pressure of defeats and casualties, influenced a movement in the opposite direction to a reassertion of civilian leadership. The two revolutions in Russia in 1917, the subsequent overthrow of the Hohenzollern dynasty in Germany, and the disintegration of the old regime in Austria-Hungary reflected the general reaction against professional military leadership.

In Germany and Russia this reaction was related to war-weariness and disillusionment with the performance of the armies in the field. But disillusionment was relatively short-lived in both countries. The German public soon regained faith in the nation's inherent military prowess and readily accepted the "stab-in-the-back" legend as an explanation for the army's defeat. In Russia, the Red Army had the good fortune to start with a clean slate, blaming defeat on the old imperial officer corps and generals who were no longer on the scene. In the early postwar years, victories over counterrevolutionary and foreign armies provided a basis on which to build a new Russian

military tradition. Nevertheless, both the Soviet and (after 1933) the German military leaders were victims of the classic suspicion which revolutionary regimes seem to harbor against the professional military class. Hitler used and rewarded the Wehrmacht leaders who were loyal to him, but kept them under tight control; Mussolini, while his power lasted, also dominated the generals; and in Russia, the purges of 1936 and 1937 were attempts to insure the communist leadership against political ambition on the part of generals. Even in Spain, under Dictator Franco, the military were unable (despite the prestige accruing from their victory in the civil war) to equal the dominating role of the Falangist party. Among the major powers, only in Japan did the military gain a steadily increasing ascendancy over the political leadership during the interwar years.

In the West, the status of professional military leaders suffered in varying measure from the widespread pacifism and antimilitarism of the years following the war. The French army, with its tradition of monarchist, Bonapartism, clericalism, and antirepublicanism, was especially suspect in the turbulent, usually left-of-center politics of the Third Republic. The British public and politicians did not readily forget the military blunders and huge casualties of the war. And so, on the even of World War II, the United States seemed most confident of the competence of its professional military leaders, perhaps because of the very limitations which tradition and the Constitution placed upon them.

During that conflict the tight rein of political control was most conspicuous in Germany and Russia. Stalin held the ranks of Marshal of the Soviet Union and Generalissimo, in addition to de facto supreme political authority, and closely guided both strategy and day-to-day military operations. Hitler coordinated the operations of all the armed forces through OKW (Oberkommando der Wehrmacht) and, from December 1941 on, personally commanded the army as well. Of all the dictators, Hitler's exercise of supreme military command was the most personal, confident, and meticulous. In addition to controlling the machinery of high command, the dictators also used another instrument of totalitarian political control over the military: direct surveillance by special agents, both clandestine and overt, at all levels of command. In Germany and Italy, substantial segments of the armed forces consisted of special elite corps (such as the SS in Germany), directly controlled by the party; and in all the totalitarian countries, dedicated party members held many key positions of command. Japan's military rulers, by contrast, held power until the last moments of the war, and in Italy, the shaky dictatorship of Mussolini, unequal to the strains of military defeat, yielded power, progressively, to the military.

Civilian control in the democracies depended more on constitutional and traditional sanctions, reinforced by special war-time arrangements. But personal leadership played a significant role. Franklin D. Roosevelt's control of the military, particularly in the direction of strategy, was both permissive and capricious—but firm. The military, for their part, showed not the slightest inclination to overstep the constitutional limits of their responsibilities. They grumbled over the President's occasional intrusions into strategic planning and demanded a degree of regulation of the national economy which neither he nor the Congress was willing to grant. But they accepted, without question, the principle of "civilian control" and, within that framework, exercised greater power over the nation's war effort than had ever before been accorded American military men.

Congress, it has been said, was willing "to trust in God and General Marshall", and the military ended the war with some \$50 billions in unused appropriations. Purely from an organizational point of view, the machinery of command and control, from the President and Joint Chiefs of Staff down to the major theater commanders (bypassing in practice the civilian service secretaries in matters of strategy), was an impressive managerial achievement in a nation that had never taken much interest in military management. The self-restraint exercised by the American military leaders in exercising the freedom of action permitted them is illustrated by an incident which occurred less than a year after Pearl Harbor. When the Joint Chiefs of Staff were informed by the President's civilian advisers that their proposed budget strained the economic capacity of the country, they lopped \$10 billions off the budget without Presidential intervention.

In Great Britain, civilian supremacy was also unchallenged during World War II. The energetic Prime Minister, who also held the post of Minister of Defense, entered far more deeply into the processes of strategy-making and the conduct of campaigns than in the United States. At the high command level, as his own memoires and those of Lord Alanbrooke testify, Churchill's tireless and insistent attention to military problems of all kinds, from decisions on major strategic objectives to technicalities of military administration or equipment design, was the despair of his chiefs of staff. Where Roosevelt refrained from reaching below the Joint Chiefs of Staff to the level of theater or field command, Churchill had no such scruples. Unlike the American system, the British formalized civilian control at the cabinet level in a small War Cabinet operating through its own Defence Committee, over which the Prime Minister, as Minister of Defence, also presided. The chiefs of staff (including a personal chief of staff to the Minister of Defence, analogous to Roosevelt's personal chief of staff) were an integral part of the Defence Committee and collectively responsible to the War Cabinet through the Minister of Defence.

Experience in Naval Warfare

The problem of command and control in naval warfare is both simpler and more complex than that involved in land warfare. It is simpler, primarily, because naval combat is conducted on a barren plane surface.¹¹ It is simpler, also, in the fact that, while variants in the formation and maneuvers of land forces are almost infinite and are limited only by numbers of men and amounts of equipment available to the fertility of imagination of the commander, water-borne organizations are self-contained. Each individual vessel is a weapon system complete in itself and incapable of alteration to conform to some changing condition of the moment.¹²

Finally, while methodology of accomplishment has changed in tempo with technological developments the basic objectives of naval operations have not altered; they resolve themselves into a comparatively few clear-cut missions. These are:

1. Command of the sea (destruction or neutralization of enemy major naval combat forces),
2. Commerce destruction,
3. Commerce protection,
4. Projection of naval power ashore: (a) naval weapons attack on enemy land targets; and (b) ship-to-shore amphibious operations,
5. Blockade, and
6. Blockade evasion.

The complexity of naval command and control lies in the fact that the naval commander has neither opportunity nor capability physically to interject his personality upon some specific segment of his command in combat. It is not uncommon for a ground-force commander to visit one of his subordinate units during a moment of crisis. The naval commander, until a few years ago, carried his flag in one of the combat units of his battle line—usually, by long custom, one of the most powerful vessels. Once combat was joined, therefore, the naval commander was confined to that particular unit and shared its fortunes; his ability to control the action limited to the use of signal communication.¹³

Until the turn of the 20th Century, when radio began to span oceanic gaps, long delay and hazard in communications made the strategic control of naval flotillas, once they were at sea, a matter of additional complexity. As a result, the general pattern of naval command and control became a melange of restrictive

initial directives and of the loosest sort of ultimate combat control. Both the fleet commander and subordinate unit commanders were thrown upon their own initiative, victims of a system in which the later approval of higher authority might be measured only in terms of adherence to doctrinal regulations, regardless of conditions of the moment. A Byng, off Minorca (1756), could be court-martialed and shot for not observing the letter of his instructions; a Porter at Puerto Rico (1823), could be castigated for upholding the dignity of the United States by armed force. In both these cases the naval commander on the spot--out of communication with his superiors--used his own snap judgment.

Against these cases, one can cite a Tattnall--under similar conditions--bringing his American squadron into action to support the British attack on the Taku forts off Tientsin in the Second Opium War (1859) because, as he said: "Blood is thicker than water." Tattnall's action received the hearty approbation of his superiors. Nor can we overlook the Trent case of 1861, when the kidnapping of Confederate commissioners from a British liner brought the United States and England to the brink of war. Wilkes' snap judgment -- arrantly illegal--brought him first a gold medal from Congress, later a slap on the wrist from his embarrassed superiors.

The advent of radio, it might be assumed, would correct this impasse between conditions of the moment and routine instructions, without undue curb on initiative. However, such was not the case on August 4, 1914, when the German warships Goeben and Breslau passed safely under the guns of HMS Indomitable and Indefatigable because the British Mediterranean commander decided against their molestation. Technically, Britain was not yet at war with Germany, though all concerned were aware of its imminence within hours. So the German ships arrived safely at Constantinople, bringing Turkey into the war and changing the entire course of the struggle. Initiative which might otherwise have saved countless thousands of lives had been throttled by restrictive command and control--though a court-martial later cleared the admiral.

The introduction of the submarine into warfare not only had impact on surface battle doctrine for command of the sea, but also on the missions of commerce protection, commerce destruction, and blockade evasion. In our own time is the extremely significant impact of the Polaris submarine missile on the mission of projecting naval power ashore. The advent of the submarine exacerbated the linkage problem of command and control at sea not only because of the difficulties of communicating with a submerged vessel, but also because the vulnerable underwater craft could rarely transmit messages without attracting unwelcome attention from hostile aircraft and surface ships.

The general communications problem was to some extent alleviated in World War II when the U.S. Navy initiated use of a "command ship"—equipped with multiplicity of electronic paraphernalia which would enable immediate and adequate communication throughout the command as well as under superior authority. In this new type of flag-ship, not a part of the battle line, the commander retained both control and liberty of movement in combat. However, this development was far from solving the problem of the detached unit commander, isolated from communication by enforced radio silence and confronted by an unexpected situation.

Finally, and particularly pertinent to the new problems of warfare, was the emergence of the aircraft carrier task force as the dominant weapon at sea. It is interesting to note that, despite the increasing complexity of naval warfare, and the growing pervasiveness and effectiveness of automated, naval command control systems, the course of the greatest sea battle in history (Leyte Gulf) was dictated primarily by independent actions of different Japanese and American admirals, acting on their independent initiative. This might indicate that the naval commander of today, despite the wealth of a sophisticated electronic linkage lying at his finger-tips, still must be ready to exercise his own initiative for decision in emergency; his situation is possibly no whit different from that of his predecessor on the quarterdeck of a wind-ship of the 16th Century.

Experience in Air Warfare

Air warfare has grown, within a fifty-year span, from the "knight errant" individual warrior clashes reminiscent of the age of chivalry to a primary element in the integrated application of combat power in modern war. Insofar as command and control are concerned, linkage has leaped from the finger-pointing, wing-wagging, and display panels of World War I air combat to highly complex and almost foolproof electronic apparatus. The strategical leap, closely following the successive unfolding of heretofore unsuspected powers has been to a great extent free of traditional preconceived, and possibly obsolescent, command and control systems inherited by both ground and naval forces.

Despite its short historical span, useful lessons or ideas may be provided by case studies of air warfare's kaleidoscopic progress. Many of them are relevant to the over-all problems of command and control today and in the future.

Like naval warfare, air warfare embraces a limited category of missions:

1. Reconnaissance.
2. Command of the air.
3. Support of ground and sea forces (this, in turn, can be broken down into missions of interdiction and close support).
4. Long-range (or strategic) bombardment.
5. Transport (which can be broken into sub-missions of combat transport support and logistical transport support).
6. Air defense.

It would appear that except for the actual melee of air-to-air combat, the execution of air missions has been more successful under a highly restrictive command and control system. For example, in air defense we have the rigid ground control and supervision of elements of RAF Fighter Command in the Battle of Britain, 1940. Squadrons were literally "led" by ground control to their designated targets and unleashed only when contact had been made. Except during the air combat itself, pilots and subordinate commanders exercised no initiative.

It would appear that the degree of success of support missions, also, has been dependent upon the rigidity of command and control exercised not only by the air component but by the supported force. However, the truth of this generalization must be verified by further intensive study of close support operations in both World War II and in the Korean War. This would entail comparison of the relative success of Marine and naval aviation and of USAF tactical support units on similar missions.

Use of land-based air power in support of naval operations also deserves detailed scrutiny. It was successfully employed by both Germany and the Anglo-American Allies in World War II. The Luftwaffe played an important part in keeping British sea power well offshore along the Scandinavian, Atlantic, and Mediterranean coast-lines. The U.S. Army Air Force and the RAF both contributed much to anti-submarine defense in the Battle of the Atlantic. In all these cases, air operations were directed by quickly extemporized and not always efficient command and control systems. This was particularly true of U.S. Army Air Force bombers operating with the Navy along the Eastern Sea Frontier of the Continental United States, and of the bomber squadron based on Ascension Island (both in 1942).

These random examples emphasize the necessity for a complete survey in depth of air warfare as practiced in the last score of years. The examples are many. One could question, for instance, the efficiency of U.S. Army Air Force command and control as exercised on Luzon airfields in the Philippines on that fateful December 8, 1941.

One could examine the causes of the costly "short bombing" in Normandy on July 25, 1944, in the breakout (Operation COBRA). Was command and control at fault in these instances? One could, on the other hand, derive valuable positive information from study of the excellent tactical air support furnished by the XIX Tactical Air Command in support of the U.S. Third Army in Patton's "race through France" of August 1944. Most valuable of all, for the future, would seem to be an analysis of the command and control exercised by the Joint Chiefs of Staff and by General H. H., Arnold in Washington over the world-wide operations of the Strategic Air Force during the period 1943-1945.

Notes

1. The main historical trends in the development of command and control are surveyed in Appendix C.
2. Analyzed in Part Two.
3. The art of the individual warrior was, of course, carried to a high state of perfection, and feudal military organization was admirably adapted to its original function--the preservation of local security in a highly decentralized society. It was, however, ill-suited to sustained, systematic warfare.
4. One of its few apparently successful manifestations--the partnership of Marlborough and Eugene--was an example of alternate voluntary subordination by one commander to the other, within the framework of ostensibly coordinate command.
5. This, however, did not preclude the assumption of personal command in time of extreme crisis. Vide, for example, Napoleon at Areola (1796) and Lutzen (1813).
6. Clausewitz' great treatise on the uncertainty and dynamism of war is still the most perceptive critique of command and control.
7. See Appendix C.
8. There was, of course, Napoleon III, a rather pathetic shadow of his great uncle; and the bizarre, terrifying Lopec of Paraguay.
9. On War, Bk VIII, Ch VI, Part B. (Trans. O. J. Matthijs Jolles, New York, Modern Library, 1943), p. 598.
10. During the closing weeks of the Civil War the Confederate Congress had thrust a similar role on the unwilling shoulders of Lee.
11. Although land masses constrict naval operations close to shore, and while the increasing range of land-based air power presents further restrictions, neither these specialized conditions nor the existing submarine terrain obstacles affect the validity of the basic statement.
12. Vide Appendix B.
13. On rare occasion a commander whose flag-ship was disabled or mortally injured in combat has successfully shifted his flag to another vessel. Vide Perry at the Battle of Lake Erie (1813).

Enclosure to Part Two

SOME HISTORICAL EXAMPLES RELATING TO THE FUNCTIONING OF MILITARY CONTROL SYSTEMS

Primarily Related to Political Control

Pre-World War I

1. Lord Germain and British strategic control in the Revolutionary War.
2. The French Revolutionary control system.
3. Exercise of command by five civilian President Commanders in Chief: Polk, Lincoln, Davis, Wilson, Roosevelt.
4. Political control of Union and Confederate forces in the Civil War.
5. The Trent Affair.
6. The relationship of Lincoln and Grant, 1864-1865.
7. Control of armed forces in modern crises preliminary to war, 1853-1956 (Crimean War, Civil War, Franco-Prussian War, World War I, World War II, Korean War, Suez-Sinai invasion).

World War I

8. Civil-military relations in Germany in World War I.
9. Civil-military relations in France, England and the United States in World War I.

World War II

10. A comparative examination of civilian control in the British and American military systems in World War II (including a preliminary analysis of prewar origins).
11. Political controls in the command and control system of Germany in World War II.
12. Political controls in the command and control system of Russia in World War II.
13. Eisenhower's decision to stop on the Elbe, April 1945.
14. Truman, Stimson, Spaatz, and the decision to drop the first atomic bomb.

Post-World War II

15. Political control of UN forces in Korea, 1950-1953.
16. Control of Allied forces during the Berlin Blockade, 1948-1949.
17. Landing of American forces in Lebanon, 1958.
18. Control of Allied reaction to the construction of the Berlin Wall.
19. Control of U.S. forces during the 1962 Cuban Crisis.

Primarily Related to Land Combat

Pre-World War I

1. The Mongol control system of the 13th Century.
2. Frederick the Great's control system.
3. The influence of revolutionary ideology in the exercise of command at subordinate levels in the French Revolutionary and Napoleonic armies.
4. Napoleon's control system (including Davout and Bernadotte at the Jena-Auerstadt, etc.).
5. Lineoln-McCleilan and Halleck-Grant in 1862; a comparative study.
6. Lee, Jackson, and Longstreet, 1862-1863.
7. Lincoln and Grant in 1864-1865.
8. Grant's control system, 1864-1865.
9. Thomas in the Nashville Campaign, 1864.
10. VonMoltke's control system, 1866,1370.
11. The Little Big Horn Campaign, 1876.

World War I

12. The German, French, British, and American staff systems at the outset of World War I; a comparative analysis.
13. Operation of the German, British, and French command and control systems in the Marne Campaign, 1914 (including the Battles of the Frontiers).
14. Operation of the German and Russian command and control systems in the Tennenberg Campaign, 1914.
15. The Battle of Lodz (Von Schaffer and the Grand Duke Nicholas).

16. British experience in controlling front line and reserve units, 1915-1918.
17. Falkenhayn and the Battle of Verdun.
18. Adaptation of the German control system to the Italian Front, 1917.
19. The Ludendorff-Hutier tactical system.
20. Phasing and management of the Allied counteroffensives of 1918.
21. Development of artillery fire-control techniques, 1914-1918.

World War II

22. German, French, and English command and control systems in the Battle of Flanders, 1940.
23. Hitler's control system on the Eastern Front, 1941-1945.
 - a. The change of direction at Kiev, 1941.
 - b. The Hedgehog defense in front of Moscow, 1941-1942.
 - c. The German summer offensive of 1942.
 - d. Stalingrad.
 - e. Hitler vs. Manstein and Model with regard to flexible defense.
 - f. The decision to defend Budapest.
24. Malaya-Singapore, 1941-1942.
25. The Philippines Campaigns, 1941-1942, 1944-1945.
26. The Burma Campaigns, 1942, 1944-1945.
27. Initiative vs. control at Anzio, 1944.
28. Clark's decision to capture Rome, 1944.
29. Controls exercised over Eisenhower by Marshall and over Montgomery by Brooke in operations at Normandy, 1944.
30. Truscott in the invasion of southern France.
31. The Ardennes Campaign, 1944-1945.
32. The Remagen Bridge.
33. Patton's Rhine crossing at Oppenheim.
34. Development of American artillery fire-control techniques, 1930-1945.

Post:-World War II

35. The decision to land at Inchon, 1950.
36. The advance to the Yalu, 1950.
37. MacArthur's command relationships with Walker and Almond,
38. JCS controls over Ridgway and Van Fleet, 1951-1953.

Primarily Related to Naval Combat

Pre-World War I

1. The Royal Navy's control system from Drake to Nelson (including consideration of the Fighting Instructions).
2. Problems of control in America's Barbary wars.

World War I

3. Admirals Troubridge and Milne in the Goeben-Breslau incident, 1914.
4. British control of surface operations in World War I (including Jutland, etc.).
5. German control over submarine commanders, 1914-1918.
6. The German navy's decision to initiate unrestricted submarine warfare.
7. The Royal Navy's response to unrestricted submarine warfare.
8. Allied convoy control in the North Atlantic, 1917-1918.

World War II

9. German control over submarine commanders, 1939-1945.
10. Allied convoy control in the North Atlantic, 1939-1945.
11. French and British naval commanders at Mers el Kebir and at Alexandria, July 1940; a study in contrasts.
12. Disengagement of the Royal Navy during the Battle of Crete.
13. Operation of high-level Japanese and American control systems at the time of Pearl Harbor.
14. Operation of the American and Japanese naval control systems in the Pacific War, 1941-1945 (includes Midway, operations in the Solomons, Philippine Seas, Leyte Gulf).

Primarily Related to Air Combat

World War I

1. Evolution of control systems for air warfare, 1914-1913.

World War II

2. German direction of air forces in blitzkrieg, 1939-1941.
3. The employment of RAF Fighter Command in the Battle of France, 1940.
4. The control of RAF Fighter Command in the Battle of Britain, 1940.
5. The American air control system in the Philippines, December 1941.
6. Development of an Allied system of tactical air warfare in World War II.
7. The Allied control system in the bombardment of Germany.
8. German control of V-Weapons, 1944-1945.
9. Japanese efforts to retain air superiority in the Solomons, 1942-1943.
10. The employment of air transports in the Arnhem-Nijmegen operation.
11. Control of German air defense forces, 1943-1945.
12. American control system in the bombardment of Japan, 1944-1945.

Post-World War II

13. Development of an American control system for air support of ground forces.
14. Employment and control of air forces during the Berlin Blockade, 1948-1949.
15. Restrictions on UN air operations over North Korea, 1950-1953.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. This brief, exploratory study demonstrates that, despite the technological developments of our times, military history is relevant to modern problems of military leadership, command and control, and decision-making. This comparability is promising. The extent and limitations of relevance can be determined only by more detailed study, applying in depth the analytical potentialities inherent in historical research, which have been demonstrated in breadth in this preliminary exploratory study. Intensive research can be specifically directed to provide guidance to Sandia Corporation in the designing of devices and procedures for an effective command and control system.

2. The task of designing devices and procedures for an effective command and control system may be compared to Aristotle's "mean" of courage--somewhere between foolhardiness and cowardice. The problem of perfecting a system which avoids both rigidity of central command and control and adventitiousness at the line of action is complicated by the need to wed decisiveness at the center with timeliness in the field. Yet no system so far devised, nor to be developed, can completely compensate for the nonquantifiable human element.

3. A sequential relationship exists between (a) the potential consequences of a kind of military action, (b) the degree of control exercised by responsible authority over such kinds of military actions, and (c) the effects of such control on initiative at subordinate levels. It is impossible to quantify the relationship, for the relative importance of each factor varies with differences in weapon systems, as well as with other tangible and intangible influences. A rigorous and detailed analysis of historical experience relevant to the modern environment of war can, however, greatly illuminate this relationship. The analysis would need to include the following points:

- a. Consequences and decision-making
 - (1) Relationship of weapon destructiveness to deployments

- (2) Effects of isolation on responsiveness to command
- (3) Effects of awareness of consequences on a decision-maker
- (4) Effects of awareness of consequences on a subordinate's responsiveness to command
- (5) Extent to which possible consequences inhibit initiative and the levels at which this is significant.
- (6) Other psychological influences of consequences on decision-making

The element of initiative in a command and control system

- (1) The importance and value of initiative at different levels of command
- (2) The dangers of initiative; variations dependent upon command levels
- (3) Factors inhibiting initiative
- (4) Encouragement of initiative within a control system framework
- (5) Minimizing the dangers of initiative
- (6) The importance of the personal history factor in the selection of responsible subordinate commanders

Control aspects of a command and control system

- (1) Relationship of weapon destructiveness to the degree of control exercised
- (2) Assurance of responsiveness to command
- (3) Extent to which there can, or should be, limitations on political involvement in military command
- (4) Control in a disaster situation
- (5) The problem of adaptation to unforeseen circumstances
- (6) Differences between control in combat, and in noncombat, crisis situations
- (7) Degree to which various requirements of control may be mutually conflicting
- (8) Dealing with potential threats to effective control

4. The basis for such analysis will be provided by a number of carefully selected historical case studies. To assure a broad and representative basis, the examples will include instances relating to political controls, as well as an equitable selection from land, sea, and air warfare.

Primary emphasis will be laid on examples from the 20th Century, but pertinent experience from the pretechnological era will provide a comparison of human reactions in widely varying environments and circumstances. The command and control factors in crises leading to war will be compared with those in crises in which war was avoided. Examples will also include both permissive and restrictive control systems, functioning under a wide variety of circumstances.

5. Relevant situations or experiences that should be studied in considerable depth are classified as follows:

- (1) Examples relative to political controls and to the military control systems for land, naval, and air combat.
- (2) Highly developed control systems in the pretechnological era.
- (3) A control system operating in a noncombat crisis leading to war.
- (4) A control system operating in a noncombat crisis in which war was avoided.
- (5) Successful operation of a permissive control system.
- (6) Failure of a permissive control system.
- (7) Successful operation of a restrictive control system.
- (8) Failure of a restrictive control system.
- (9) Example of a restrictive control system established primarily for political purposes.
- (10) Success of an allied control system.
- (11) Failure of an allied control system.
- (12) Successful instance of direct political intervention in military operations.
- (13) Failure of a direct political intervention in military operations.

- (14) Successful high-level military intervention in subordinate conduct of operations.
- (15) Failure of high-level military intervention in subordinate conduct of operations.
- (16) Breakdown of a control system due to faulty doctrine.
- (17) Breakdown of a control system due to command failure.
- (18) Breakdown of a control system due to human "friction".
- (19) Breakdown of a control system due to communications failure.
- (20) Breakdown of a control system due to intelligence failure.
- (21) Breakdown of a control system due to fortuitous or unexpected circumstances.
- (22) Breakdown of a control system due to enemy action.
- (23) Breakdown of a control system due to "overloading" or insufficient reaction time.
- (24) Example of decision-making in disaster circumstances.
- (25) Example of subordinate decision-making in a relatively isolated environment.
- (26) Example of successful subordinate initiative in a permissive control system or after a control system breakdown.
- (27) Failure of subordinate initiative in a permissive control system or following a control system breakdown.
- (28) Successful circumvention, or deliberate violation, of restrictions on part of subordinate commander.
- (29) Failure resulting from circumvention, or deliberate violation, of restrictions on part of subordinate commander.
- (30) Failure of a subordinate to comply with commands, due to his awareness of exceptional consequences of the required act.

6. We have selected twenty-one case studies (all containing aspect relevant to modern problems of command and control) from the list contained in Part Two to meet the criteria of paragraphs 3 and 4, above.

A list of the selected case studies, with a brief statement indicating their relevance to the problems of decision-making and initiative in command and control systems may be found in Enclosure 1. Enclosure 2 contains a matrix relating the twenty-one selected case studies to the criteria listed in paragraph 5, above. This matrix will also help to suggest which aspects of these case studies warrant the most detailed attention.

7. The exploratory analysis undertaken in Study "Pre-Alert" indicates that historical experience provides useful insights into other aspects of the always variable problem of command and control. Some of the data which have already emerged in this study, though not directly relevant to the development of techniques and devices for modern command and control systems, are of such significance to coalescing concepts and doctrines of civilian and military leadership and of command and control systems in the modern world as to merit prompt attention. The specific additional areas which we believe deserve such immediate and serious study by Sandia Corporation or appropriate governmental agencies are the following:

- a. The problem of recognizing and developing qualities of initiative and creative leadership in the environment of modern, largely automated, command and control systems.
- b. The relevance of military command and control systems to the American concept of "civilian control".
- c. Pertinent Presidential experience in military command and control since the Mexican War.
- d. The concepts and underlying issues involved in the development, before World War I, of the General Staff system, the organizational origin of modern command and control systems.
- e. The problems of command and control of multinational, multilingual allied forces, including the effects of different cultural backgrounds, values, military traditions and concepts, and levels of economic development on communications, responsiveness to command, initiative, and related subjects.
- f. Specified historical turning points in warfare prompted by the integration of new weapons, or concepts, into then-traditional methods of waging war, to ascertain the relative importance of the factors producing the change, in order to gain insights into the comparable problems faced by today's planners who seek to guide the transition from "conventional" warfare into the nuclear era.

Recommendations

HERO recommends:

1. That an intensive, critical study be undertaken of historical experience relevant to the introduction of devices and procedures affecting military decision-making into a modern command and control system. An outline and a detailed working plan for this study, entitled Study "Alert" are being submitted.

2. That additional areas for related study in the subject of command and control, as suggested in paragraph 7 of the Conclusions, be considered for further research.

SELECTED CASE STUDIES FOR INTENSIVE INVESTIGATION
OF COMMAND AND CONTROL ASPECTS

¹• The Mongol System of command and control, 13th Century.

An example of a strategic and tactical command and control system, operating in the pretechnological era, but involving conditions that may well prove applicable to modern battlefields. As with nuclear weapons, the Mongol system could wipe out populations and civilizations, even though at lesser speed. On the battlefield, the Mongols operated over vast distances with minimum resources, maneuvering from both fixed and mobile bases with powerful hit-and-run tactics in a manner that may well be applicable to the nuclear battlefield.

²- The Royal Navy's control system from Drake to Nelson.

An example of the development and effects of a highly restrictive command and control system, strictly enforced over a number of years, and the influences which led to its later disappearance in favor of a less centralized, permissive tactical system.

3. Political control of armed forces in modern crises preliminary to war, 1853-1956.

This period provides the opportunity for studying international crisis leading to war under an instructive variety of political, military, and technological conditions. Wars studied will include the Crimean War, U.S. Civil War, Seven Weeks' War, Franco-Prussian War of 1870, Russo-Japanese War, Boer War, World Wars I and II, the Korean War, and, possibly, lesser conflicts.

4. Operation of the British naval control system during the Goeben-Breslau incident, 1914.

A brief, but illuminating example of the problems of effective command and control in a non-combat crisis situation in which war is imminent, including the consequent frustrations to local commanders confronted by a dangerous, unforeseen situation fraught with political and military implications.

⁵• Operation of the German, British, and French command and control systems in the Marne Campaign, 1914.

An example in military history in which there was an almost complete breakdown of communications and linkage within the German armies and, to a lesser extent, within the French and British armies. There was also a similar breakdown in linkage between the French and the British Allies. This involved several instances of exercise of subordinate initiative following a control system breakdown or degradation. That these events occurred in the opening stages of an era of vast, unforeseen changes in warfare provides added instructiveness.

6. Operation of the German and Russian command and control system in the Tannenberg Campaign, 1914. Similar in some respects to the Marne Campaign, this example is particularly useful because of the way in which a command and control system recovered from near collapse due to the independent but coordinated efforts of several highly trained professionals, at least one of whom also exhibited an exceptional degree of initiative to exploit the opposing system's breakdown.

7. Control of German submarine operations in World Wars I and II.
TL. An example of the political problems of employing exceptional weapons in modern war, including useful examples of problems of control of dispersed units with difficult linkage arrangements, as well as the actions and reactions of isolated subordinates.

8. Control of Allied convoys in World Wars I and II.
Examples of highly restrictive, yet highly successful command and control systems. The linkage and control techniques are particularly relevant.

⁹- Development of American artillery fire control systems, 1917-1945. Concerned with the evolution of perhaps the most highly specialized and effective technological control system to be developed for an instrument of land warfare prior to the nuclear age, this study should have direct relevance in terms of hardware to the problems faced by the Sandia Corporation today.

¹⁰• German, French, and English command and control systems in the Battle of Flanders. .1140^" An example" of a highly successful German tactical control"system in a new era of warfare, as opposed to a collapse of the French system intensified by political intervention. The British system, on the other hand, continued to function under adverse circumstances, also in the face of political intervention. Even more significant was the political involvement on the German side.

11. Control of RAF Fighter Command in the Battle of Jrita in.
The successful operation of a highly centralized "and "re-strictive command and control system (which was also extremely permissive within narrow limits) under adverse conditions in one of the decisive battles of world history.

¹²• Hitler's control system on the Eastern Front, 1941-1945.
This is probably the most clear-cut example in modern times of the imposition by a head of state of centralized control over field operations. As such, it is extremely pertinent to Study "Alert".

13. Operation of the American and Japanese command and control systems in the Philippines Campaigns of 1941-1942 and 1944-1945. Several kinds of pertinent experience are encompassed in these campaigns, e.g., the complete breakdown of American Air Force command and control at the outset; and the interesting comparison of the operations of American and Japanese commanders confronted by a dangerous, unforeseen situation fraught with political and military implications.
14. Operation of the Japanese and Allied command and control systems in the Burma Campaigns of 1942 and 1944-1945. Provides a useful comparison to the preceding example through parallels and differences, but also with greater political complications on both Allied and Japanese sides.
15. Operation of the American and Japanese naval control systems in the Pacific War, 1941-1945. Individual examples of success and failure of control systems will be elaborated as well as instances of the exercise of initiative by subordinate commanders on both sides, actions in disaster situations, action in isolated circumstances, etc.
16. Initiative versus control in the Anzio and Rome Campaigns in Italy, 1944. These two operations involved much the same cast of characters in two widely differing kinds of operations, in both of which there were issues of Allied differences. The first shows a relaxation--virtual abnegation--of command responsibility by a higher commander, resulting in a highly controversial decision by the subordinate. The second shows the circumvention of command by a subordinate.
17. The Ardennes Campaign of 1944-1945. A highly instructive comparison of German, American, and British command and control systems under circumstances far different than those in 1940. The political influences on both sides are significant, as are also the manners in which intermediate field commanders reacted to opportunities for initiative.
18. Allied air control systems in the bombardment of Germany in World War II. Examples of both restrictive and permissive control systems, including numerous instances of exercise, of subordinate initiative, failure to use initiative where it might have been expected, and the frustrations of commanders under extreme provocation by uncooperative or unfriendly allies (Russian).

19. Development of an American control system for air support of ground forces. Demonstrates the problems of evolving "a satisfactory control system to meet a wide variety of requirements, including examples of system breakdown, or degradation, in World War II and the Korean War. This is an illustration of a wide variety of technical and psychological problems in a still-current and controversial issue of command and control.

20. Political control of American forces during the Berlin crises of June 1948 (beginning of the Blockade)" and" July 1961 (construction of the Wall). A highly pertinent nuclear-age"~ example, in which the crises did not lead to war but were fraught with incendiary possibilities which could have precipitated conflict. Coordination among allies at the highest political level, as well as at military operational echelons, figured prominently in the crises.

²¹ • Political control of United Nations forces in Korea, 1950-1953. One of the few modern examples of political control over a truly multinational army. It al.**SD** provides an opportunity to study an example of limited war where various possibilities for escalation (including nuclear weapons) were present but were avoided despite, in some cases, considerable pressure from military leaders.

ENCLOSURE 2

Matrix Comparing Selected
Case Studies to Kinds of
Examples to be Investigated

	ENCLOSURE 2																													
	Matrix Comparing Selected Case Studies to Kinds of Examples to be Investigated																													
	1. Monocro Svstem	2. Pre-War Crises. 1853-1956	3. Goeben-Breslau	4. Marne Campaign	5. Tannenberg Campaign	6. German Subs, WW I & II	7. Allied Convoys, WW I & II	8. Am. Artillery Fire Control	9. Battle of Flanders. 1940	10. Battle of Britain, 1940	11. Hitler. East Front. 1941-45	12. Burma, 1942, 1944-45	13. Ardennes. 1944-45	14. Allied Bombardment of Germany. WWII	15. American Air Support to Ground Forces)	16. American Air Support to Ground Forces)	17. American Air Support to Ground Forces)	18. American Air Support to Ground Forces)	19. American Air Support to Ground Forces)	20. American Air Support to Ground Forces)	21. American Air Support to Ground Forces)	22. American Air Support to Ground Forces)	23. American Air Support to Ground Forces)	24. American Air Support to Ground Forces)	25. American Air Support to Ground Forces)	26. American Air Support to Ground Forces)	27. American Air Support to Ground Forces)	28. American Air Support to Ground Forces)	29. American Air Support to Ground Forces)	30. American Air Support to Ground Forces)
1. a. Political Situation		x	x																											
b. Land Situation	x	x		x	x			x	x		x	x	x		x															
c. Naval Situation		x	x	x		x	x																							
d. Air Situation			x				x		x	x		x	x	x					x	x	x	x								
2. Pre-technological example	x	x																												
3. Non-combat to war			x	x																										
4. Avoidance of war			?																											
5. Successful permissive	x	x	x		9	x	x		x	x	9		x	x	x	9	x	9	9											
6. Failure, permissive			x	x	9	x	9		x		9		x	x	x	x		9												
7. Successful restrictive			x			x	x			x	x							9	x	9										
8. Failure, restrictive	x	x				?																								
9. Restrictive, primary pol.			x																											
10. Successful Allied			9				x							?	9	x														
11. Failure, Allied			?		9				x					9	9															
12. Successful pol. intervention			x			9	x		?		x			?																
13. Failure, pol. intervention			x			9					x			9																
14. Successful mil. intervention	x				x	x	x	x	x					x	x			9	9											
15. Failure, mil. intervention		x			9				x					x	x	x	9	?	9											
16. Breakdown, faulty doctrine	x			9		x			x					x																
17. Breakdown, command failure				9	x	x			x		x	x		x	9	?														
18. Breakdown, human friction					x	x					x	x	x	9	9															
19. Breakdown, comm. failure	x	9		x	x	9					x																			
20. Breakdown, intell. failure			9		x									x	x		x													
21. Breakdown, unexpected sit.	x	9	9			9					x			9																
22. Breakdown, enemy action					x	x			x		x	x	x	9																
23. Breakdown, overloading			x						9	9		9	9	9																
24. Disaster situation					x				x		x	x	x	9																
25. Isolated situation						x	9	x		x	9			x	9		9	x	9	?	9									
26. Successful initiative		x	9		9	9	?	x		x	x	9		x	9	x	9	x	x											
27. Failure, initiative		x	9		9		9					9	?	x	x	9		x	x											
28. Successful circumvention		x	?								x			9	9			9	9											
29. Failure, circumvention		x	9											9	9			9	9											
30. Failure due to consequences			x	x		9												?		x	x									

Appendix A

GLOSSARY

Administration: In its broadest sense, this comprises all military activity which is not operational. Thus it covers matters pertaining to materiel, facilities, services, and the provision of personnel. The most important part of administration is logistics, which has to do with the physical support, maintenance, and, above all, supply of armed forces. The words "logistics" and "administration" are sometimes used interchangeably.

Authority: The clearly understood status of an individual which permits him to issue commands to, and to exercise control over, subordinates.

Chain of Command: The successive commanders through which command actions are channeled. The chain of command extends downward from superior to subordinate and upward from subordinate to superior.

Command: The authority which a military officer exercises over his subordinates because of his rank and/or his assignment to a position of responsibility by recognized, properly constituted authority.

Command and Control: A general, and somewhat imprecise, term of relatively recent origin which refers to the process by which a commander exercises control, particularly employed with respect to long-range nuclear striking forces or to defensive forces created primarily for the eventuality of a general nuclear war. The term is usually considered to include the entire process of military decision-making, beginning with the collection of intelligence, its transmission to a commander's headquarters, the evaluation of the intelligence, the estimate of the situation, the decision, the issuance of orders or directives, and the assured receipt, and proper interpretation, of directives by subordinates. An important aspect of this concept is the communications linkage which carries the intelligence and other information to the commander and which transmits the directives to subordinates.

Communications: As used in this study, this refers to all physical means of transmitting messages, information, or orders from one element of a military force to another (see Linkage).

Control: This is the process whereby a commander effectively directs military forces so that they are fully responsive to his will. Control requires adequate means or measures to ensure the cooperative and coordinated efforts of subordinates in carrying out his command assignment; it includes the organization of forces for combat, the assignment of tasks to subordinates, the designation of objectives, and the authoritative direction necessary to accomplish the mission. Control depends on mutual recognition of authority by superiors and subordinates.

Decision-Making: This is the entire process by which a commander reaches a conclusion on several alternative courses of action open to him. The process includes consideration of all factors relating to the issue. It includes correlating and evaluating intelligence, estimating the known military situation at the time, and usually formulating the specific conclusion into the form of an order to be issued to subordinate commanders.

Doctrine: Principles, policies, and concepts which are combined into an integrated training system for the purpose of governing, and assuring consistent, coordinated employment of, all components of a military force in combat. The origin of doctrine can be experience, or theory, or both. Doctrine represents the best available thought on the employment of forces that can be defended by reason. Doctrine is methodology and, for it to work, all military elements must know, understand, and respect it.

Escalation: An increase in the scope or intensity of an armed conflict. In its most common use, the term is used to refer to a possible change of a limited war (nuclear or conventional) to an unlimited nuclear war. It is also used to refer to any kind of stepping up in combat intensity, such as from undeclared guerrilla war to a declared formal war or from a war involving a small number of participants to one involving a larger number of participants.

Linkage: As used in this study, the term means the physical means and measures whereby a commander exercises his control and assures the coordination of all elements of his command. The principal form of linkage is a signal communications system, which can include all manner of electronic devices which transmit information and directives from one element of a command to another. It can also include liaison, staff visits, or any other means whereby an exchange of information, or the transmission of orders, can be effected.

Logistics: See Administration.

Operations: All those aspects of military activity directly pertaining to combat engagements. This includes matters that are both strategic and tactical. Matters connected with operations are also called operational.

Responsibility: The obligation to carry an assigned task to a successful conclusion. It is axiomatic in military doctrine that responsibility should include the authority necessary to direct and to take proper actions essential for carrying out the task. Responsibility also includes accountability for failure to accomplish the task successfully.

Staff: A group of assistants upon whom a commander relies for study and recommendations relating to all factors affecting the accomplishment of his mission and for the transmission of his desires to subordinate commanders. Staff action consists of coordinated translation of the commander's decision into the minute details of operations and supply. The members of a staff do not assume the commander's responsibilities, though with his permission they may invoke his authority; their role is merely to assist the commander in reaching sound decisions and otherwise exercising his command obligations.

Weapon System (or weapons system): A general and imprecise term of relatively recent origin, possibly more useful to military budget management than to operational concepts. The standard military definition is: "The system which encompasses the weapon or weapons and associated materiel employed to bring the destructive power of the weapon against the enemy." This, however, is considered inadequate for purposes of this study, and the following definition is substituted:

A weapon system is an aggregation of men, weapons, and associated materiel, organized to operate together in response to the directives of higher authority, and in accordance with a coherent, explicit, and clearly understood operational doctrine, in such a way as to exploit the destructive or casualty-inflicting capability of a particular type of weapon, or complementary group of weapons. A weapon system can be designed to operate independently, or as a discrete element of a larger combat force; the larger combat force may, in turn, be considered as a weapon system if its mission is primarily concerned with the employment of a particular type of weapon or complementary group of weapons. Thus, a warship, a basic unit of combat aircraft, a basic unit of combat ground troops, or a long-range missile unit—along with their respective noncombat supporting elements—could each be considered as basic weapon systems. At the same time, larger groupings of identical, similar, or complementary basic weapon systems can, in turn, be considered as weapon systems; for instance: carrier task force, a submarine hunter-killer group, an infantry division, an armored division, a tactical air wing, a long-range bombardment wing, a complex of long-range ballistic missiles.

Appendix B

SURVEY OF WEAPONS AND WEAPON SYSTEMS IN HISTORY

Introduction

Throughout the course of history, weapons have been the principal determinant of military operational doctrine. The elaboration of this doctrine has resulted in the grouping of weapons, fighting men, and supporting equipment into a kind of structure or organization best calculated to ensure optimum tactical employment of the basic weapon or weapons in combat. In relatively recent times, the groupings of weapons, men, and ancillary equipment have been somewhat loosely described as "weapon systems".* Since a major consideration of military decision-making must be the proper tactical employment of weapons and weapon systems, this historical survey is intended as a backdrop for surveys of the history of command and control.**

In addition to the general discussion of weapons and weapon systems in history, in this text, the time-span of weapons in history and the relationship of the time-span to weapon systems is graphically shown in four enclosures.

The Age of Muscle

From prehistoric times, through antiquity and the bulk of the Middle Ages, to the first decisive application of gunpowder (about A.D. 1450, in the Hundred Years' War, and A.D. 1453 at the siege of Constantinople), man himself was the propelling force behind the weapons he employed in warfare. Though there were two basic weapon groups—missile (the hand-hurled rock, the sling, the bow, the javelin, the catapult) and shock (the club, the spear, the pike, the lance, the sword)—both depended mainly for thrust or propulsion on the muscle of man.

Human muscle power was augmented by a number of mechanical devices such as the lever and the pulley as well as gravity, tension, and, especially, torsion. The bow and arrow enabled man to hurl his missile faster, further, and more accurately. Augmentation of human strength was provided, of course, by the horse, the chariot, and the elephant, but these, too, were merely another form of animal muscle power and were wielded or controlled primarily by the hand of man. Thus, the age of warfare prior to the application of the propelling force of gunpowder may be classified as the Age of Muscle.

*See definition, Appendix A

**See Appendices C and D

From Prehistory to the Decline of Rome

Many of the weapons developed in primitive times were carried over into the early historic periods of warfare in one form or another. Their basic improvements were due to the introduction of metals—first bronze and later iron. The arrow, for example, changed little for two millennia except that rather than being tipped with stone, it later bore a head of metal. The club and, later, the axe underwent similar change. Perhaps the first new weapon of the metallic era was the sword, though even this weapon had its prototype in the stone dagger and the stone-tipped javelin and spear of prehistoric times. On the other hand, the thin blade of the sword could not have been created until metallurgy had advanced sufficiently to permit the working of hard malleable metal, in the Bronze Age sometime before 2000 B.C. Thus, the sword was probably introduced by the Egyptians, or possibly the Assyrians. During this same period, protective armor, both body armor and the shield, also was improved, though leather remained the basic material for armor for many centuries.

Rudimentary weapon systems—in the sense that tactical groupings for delivery of weapons are weapon systems--began to develop sometime before 1500 B.C., when warriors were first grouped according to their weapons, missions, and relative mobility. The basic component of armies was a large unwieldy mass of foot soldiers, or infantry, as they would eventually be known. These men could carry various forms of thrusting spears or pikes and were protected by little or no armor. There were also foot skirmishers with missile weapons: archers, slingers, and javelin throwers.

Infantry was not, however, necessarily the decisive arm. This role usually fell to a contingent of small, horse-drawn, armored carts or chariots, sometimes equipped with sharp blades projecting from the wheels. Or often men on horseback, later known as cavalry, usually operating from the flanks of the great mass of infantry, were decisive. Yet, horses were expensive, and men on foot were numerically predominant; the cavalry was an elite force.

Little organization, training, discipline, or tactics existed in these early armies. While a skirmishing screen of archers and slingers maintained harassing fire in the front, the infantry spearmen were more or less herded together in great masses, a hundred or more in depth, while nobles, on horseback or in chariots, took position on the flanks to await a propitious moment for decision.

Not until approximately 700 B.C., in Assyria, did armies begin to take on those characteristics of organization and tactics that were to persist in one form or another through the ages; weapons remained much the same. But about 600 B.C., mounted archers originating in the heart of Asia—the Scythians of antiquity—became the principal element of a new military power appearing on the Persian plateaus; and Persian cavalry became the mainstay of Cyrus' and Darius' armies.

Soon after this, amid the rocky hills of the Greek mainland and the Aegean Islands, there developed what may be called the first true weapon system: the Greek phalanx, a disciplined body of heavy infantry. Called a hoplite, the individual infantryman was armed with an eight- to ten-foot pike and was protected by metal helmet, breastplate, greaves, and shield. While archers delivered harassing fire, the hoplitai were arrayed in long, solid lines varying in depth from eight to sixteen men, protected on the flanks by lightly armed troops and, sometimes, by small contingents of cavalry. Everything was designed to contribute to the shock effect of the solid mass of the phalanx. In 490 B.C., the defeat of the Persians in the Battle of Marathon proved dramatic evidence of its power.

Beginning with the 5th Century B.C., the catapult and ballista, weapons which could be called artillery, began to assume a noteworthy place in warfare. Both were wooden, crew-served weapons. The catapult used the force of tension to propel large arrows up to 500 yards, while the larger ballista employed the force of torsion to hurl large rocks for comparable distances. Though Philip of Macedon and his son, Alexander, introduced catapults and ballistae to field operations, the weight and unwieldiness of the weapons dictated that they be employed principally in siege operations.

Siege warfare was not new. Walled cities, and efforts to breach them, had puzzled warriors from prehistoric times. Many ways to deal with fortifications had been developed: blockade; destroying food sources; the battering ram; the movable tower; large shields (leather, wicker or wood) to protect besiegers; flaming arrows; and digging or mining to undermine walls. Extensive field fortifications were apparently used first by the Romans, who formed camps which were protected by trenches and by palisades composed of stakes carried by the soldier as part of his individual equipment.

The phalanx remained the basic ground weapon system for a long time. Even Alexander's use of "field artillery" and, in particular, his effective employment of heavy and light cavalry were designed to contribute to the effectiveness of the heavy phalanx and his disciplined light infantry. Whereas Philip had made each large unit a separate phalanx, leaving intervals between units, Alexander subdivided the phalanx into four chiliarchiae which, for maneuver, were further subdivided into four 250-man syntagmae that could wheel about when faced with threat on a flank. The aggressive, fast-moving Macedonian phalanx, with its 21-foot pikes (sarissas), was the epitome of the phalangial system and, for more than a century, remained the dominant tactical system in the world.

As the phalanx was superseded by the Roman legion (in the 3rd and 2nd Centuries B.C.), no major new developments appeared in small arms; there were, however, some significant refinements, such as the Roman gladius (short sword) and pilum (javelin). Moreover, a unique departure in weapons had been forcibly brought to Western attention in 326 B.C., when elephants were encountered during Alexander's campaign in India. Both Pyrrhus and Hannibal subsequently used elephants against the Romans but, in general, disciplined foot-troops accustomed to the beasts were able to stand against them and to induce them to stampede.

During the course of its long existence, the legion underwent various changes. In its earliest and best days, it consisted of approximately ten cohorts, totalling some 4,000 men. Each cohort was further subdivided into four maniples, plus a small contingent of cavalry. In battle, the legion was usually arranged in three lines: the maniples (each a small, loose phalanx with intervals sufficient to permit each legionnaire to wield his sword) were deployed with intervals between maniples so that they were in a quincunx or checkerboard formation; the maniples of the second line covered gaps in the first; and those in the third line covered gaps in the second. The true genius of the legion organization lay in the combination of flexible maneuverability and solid defensive capability of the maniples, which numbered 120 men. And military professionalism and fervent patriotism were integral components of the legion as a weapon system.

During the wars of the Roman Empire, cavalry played no more than a supporting role, though in Asia, at the same time (in the Han Empire of China and in the Parthian Empire of a new Persia), cavalry remained the major arm. In both China and Persia this development was forced by incursions of fierce tribes of Mongoloid and Indo-European peoples from Mongolia and Turkestan, whose only type of warrior was the Scythian-type horse archer. Among the Asian peoples, the Indians alone failed to make widespread use of the horse (paradoxically, the stirrup may first have appeared in India, possibly in the First Century B.C.).

In the early centuries of the Christian era, the Roman legion gradually declined in combat quality for many complex reasons; at the same time, barbarian pressure against the Empire's frontiers steadily increased. To give greater offensive and defensive strength to the weakening legion, the Romans increasingly utilized small mobile catapults and ballistae which became the organic infantry support weapons within cohort and legion. But the pressures of mounted Germanic and Asiatic barbarians culminated in the Roman disaster at Adrianople in A.D. 378 which caused a shift to armored cavalry from reliance upon a decaying legion. Thus, Adrianople was one of the great turning points in military history.

The Middle Ages

In the years after Adrianople, as the Romans adapted themselves to cavalry, and as raids and incursions by barbaric tribes increased, there were few new weapons introduced. A possible exception was the vicious francisca, a heavy battle-axe employed by Frankish infantry either as a projectile or as a bludgeon. A major refinement was the heavy lance, which came to be employed by a warrior wearing chain mail and sitting on a similarly protected horse. The saddle with stirrups, provided this armored horseman, a prototype of the feudal knights, with the firm base that was essential for his shock role. Additional shock effect was gained by new breeds of heavy horses from Persia and Central Asia. Heavily armored horse archers shared the primary fighting tasks for the declining Empire, while heavy infantry was relegated to a secondary role. The legion became essentially a phalanx, but in a passive, defensive, often stationary role, and as such was a base of maneuver for the cavalry. This development was to some extent a reversion to the military system of Cyrus the Great.

While the Western Roman Empire declined and fell (A.D. 476), the Eastern Empire (surviving as Byzantium) was perfecting armored cavalry and developing a highly sophisticated military system built around the turma (or division) of heavy horse archers. The Byzantines also introduced a new decisive weapon—Greek fire, initially employed during the first Moslem siege of Constantinople in A.D. 673. Apparently a mixture of sulphur, pitch, niter, petroleum, and, probably, quicklime, which burst explosively into flame when wet, the material was packed into tubes and squirted onto hostile vessels. It clung to whatever it hit and burned fiercely. The Mohammedans later adopted the weapon, and used it against the Crusaders several centuries afterward (notably, at the siege of Acre, 1190, when they threw jars of Greek fire from the walls to destroy the Crusaders' siege machines). Yet, for all the effectiveness and terror of the weapon, the secret of making Greek fire has not survived.

Though military art and science degenerated in Western Europe after the fall of Rome, there was no dearth of military action during the darkest period of the Middle Ages. Worthy of mention are: the spread of Islam by military power, the military system of Charlemagne, the raids by the Vikings, the Crusades, the terrifying conquests of Genghis Khan and his Mongol successors, and the Hundred Years' War. Yet, improvements in weapons were relatively few. The most significant development in tactical organizations—and thus in weapon systems—was the amazingly efficient and scientific tactical system created by Genghis Khan from the Asiatic horse archer of antiquity. In this system, the principal element was the touman of 10,000 men, composed of 10 regiments of 1,000 men each, and subdivided, in turn, into 10 squadrons, each comprising 10 troops. Three toumans made up the horde—roughly equivalent to an army or army corps. Voice, trumpet, and drum, plus a semaphore-type system of black and white battle flags provided signals for a well-developed system of battlefield tactics.

The Mongol battle formation was composed of five lines, each of single rank, with large intervals between the lines. The first two lines comprised the heavy cavalry, with mixed lancers and archers; the other three were made up of light horse archers only. Reconnaissance and screening were carried out in front of these lines by light cavalry units. As the opposing forces drew near, the three rear Mongol ranks of light cavalry advanced through intervals in the two heavy front lines to shower the enemy with javelins and arrows. If this preliminary long-range missile assault did not scatter the enemy, the light horsemen retired and synchronized signals started the heavy cavalry on its climactic charge.

In Europe, the armored, mounted, shock-action knight (or man-at-arms) was supreme in field operations. Despite lack of discipline and a tendency toward fractiousness and insubordination, the combination of chivalry, mobility, and the combat power of these highly skilled, heavily armed and armored horsemen produced an elan and striking power that could overwhelm larger numbers of most opposing combinations. The knight, however, was frustrated by the improvement of fortifications, which reached a zenith with the feudal castle of the 14th Century. Nevertheless—employing the castle as a base—small, mobile, mounted armies could strike swiftly and deeply into enemy territory, even though the limitations on feudal obligations prevented sustained operations. This relative mobility remained the principal characteristic of the knight, even though his body armor became heavier and heavier (culminating in plate armor in the 13th and 14th Centuries).

The gradual increase in the weight of armor resulted largely from the introduction of the 11th Century crossbow, a radically different hand weapon, incorporating the principle of the ballista. This was so terrible in its effect that the Vatican attempted to outlaw it for use by Christian against Christian. The first recorded use of the crossbow was by William the Conqueror at the Battle of Hastings in 1066. The Crusaders later seized upon this weapon to counteract the horse archers of Islam. Though cavalry sometimes used the crossbow, it evolved primarily as an infantry weapon, since it was more accurate in the hands of the foot soldier. It was an early harbinger of the infantryman's return to pre-eminence on the field of battle.

More significant to the resurgence of the infantryman was the introduction of a radically modified old weapon, the longbow, as dramatically demonstrated by Edward III at the Battle of Crecy in 1346. The secret of Edward's success, however, did not stem from the use of the longbow alone, but from employing a judicious combination of dismounted knights, archers, and mounted cavalymen which produced a flexible combination of missile firepower, defensive staying power, and mobile shock action. Crecy reversed the verdict of Adrianople, and infantry once again became master of the battlefield.

The English tactics for employment of the longbow were essentially defensive. It remained for the Swiss, introducing an organization and method of combat amazingly similar to the Macedonian phalanx, to assert the superiority of disciplined infantry over cavalry in shock action. The Swiss demonstrated that massed pikes in unwavering, close-packed formation could be more terrifying to horse and rider than the cavalryman was to the pikeman. Their system required excellent organization, rigorous training, and iron discipline of a sort unseen since Roman times. For the most part, the Swiss marched and fought in heavy columns, with a frontage rarely exceeding 30 men, but often 50 to 100 men deep. They marched in cadence, often to music. In addition to basic pikemen, the formations included a few crossbowmen as skirmishers and a number of men in the interior ranks armed with the halberd, a modified pike. This was, in effect, an axe head added near the point of the pike on one side, with a hook on the other; it was more effective than the pike in close combat against enemy horsemen. For over a century, until gunpowder revolutionized weapon systems, Swiss pikemen were dominant in European warfare.

Early Naval Weapon Systems

Prior to the 7th Century B.C., employment of ships for warlike purposes was limited largely to transporting soldiers and supplies in merchant ships, essentially adjunct to land power. About 700 B.C., the Phoenicians introduced the first vessels designed essentially for fighting. These were speedy, oar-propelled galleys, longer and narrower than the typical merchant ship. But it was the Greeks, particularly the Athenians, who improved the galley and introduced navies as a true new dimension in warfare. The Athenian trireme, as it developed about 500 B.C., was a long, narrow vessel, propelled by 100 to 150 oarsmen and equipped with a metal beak for ramming the sides of enemy vessels. Yet, ramming was difficult to accomplish, and reliance more often was placed on coming alongside and boarding. The Athenians achieved this by swerving unexpectedly, shipping oars at the last moment, and breaking those of the surprised foe. Though the trireme carried sails for auxiliary power, oars were the means of propulsion in actual battle. Since the trireme was not seaworthy in bad weather, it remained close to land and most naval action took place not far offshore.

During the 3rd Century, B. C, the larger quinquireme was introduced. Its complement consisted of 200 to 250 rowers and seamen, supplemented by a small force of sea-going soldiers or marines. Except for these increases in size, the only innovation in sea warfare followed the introduction by the Romans of a combined grappling device and boarding bridge called the coryus. The corvus, developed to neutralize Carthaginian superiority in seamanship, accomplished its purpose. Later, Octavian's admiral, Agrippa, introduced the harpax or harpaxe, a pole with a hook on the end. It was shot from a catapult, to be imbedded into the side of an opposing ship for grappling purposes. This was particularly effective at the Battle of Actium (31 B.C.), when Octavian routed the naval forces of Antony and Cleopatra.

Few additional innovations occurred in naval warfare until the latter half of the 7th Century A.D. when the Byzantines, reacting to growing Moslem seapower, built up a navy composed of relatively small, light, fast galleys, most with two banks of oars, two masts, and lateen sails. A small force of marines continued to supplement the oarsmen. Though the larger warships had revolving turrets mounting war engines, the most deadly weapons were the bow tubes from which the dreaded and deadly Greek fire was hurled with explosive force.

In the Middle Ages, naval warfare remained much the same, or else degenerated. The last thing, for example, that raiders like the Vikings desired was battle at sea. Yet, by the 12th Century, the rise of Italy and Sicily as thriving maritime nations, which transported Crusaders to their Holy Wars, presaged a return to importance of armed strength at sea. The oar-driven galley was still the basic warship, though some improvements in sails appeared, particularly in northern Europe. Even the advent of gunpowder had, at first, no revolutionary effect on naval weapons and tactics; but later, in the English Channel in 1588, when Spain's "Great Armada" was repulsed by broadside sailing ships, naval warfare entered a new phase.

The Age of Gunpowder

Early Gunpowder Weapons

Though gunpowder weapons were possibly first employed at Crecy, they had little or no effect on the outcome of the battle. Not until the end of the 15th Century were these weapons developed to the point that they could be ascribed as indubitable arbiters of the battlefield.* At first, size was the only distinction between small arms and artillery. Both were simple iron tubes, ignited by means of a slow-burning "match" (a cord soaked in saltpeter and then dried) which was touched to powder sprinkled in a "priming pan"; this being a slight depression on top of the tube, connected to the powder inside by a touchhole. Small arms were extremely inaccurate; artillery was no better.

Sometime before mid-15th Century, development of the matchlock--an S-shaped mechanism often called a serpentine, which held a burning cord-match and was attached to the side of the weapon--increased handgun efficiency. By means of a trigger, the serpentine could be applied to the priming pan and touchhole, now moved to the side of the gun. The matchlock led in turn to development of a butt piece, improved after mid-century into a curved or bent stock that prompted the name arquebus (or

*Early in the 15th Century, crude siege artillery made the feudal castle, or so-called vertical fortifications obsolete. Gradual development of a new type of so-called horizontal fortification provided for the 16th Century fortress a degree of impregnability comparable to that of the 13th Century. The Frenchman, Vauban, brought the art of horizontal fortification to new heights in the 17th Century.

hook-butt). The effective range of the arquebus was only about 100 yards, explaining in part why the English were slow to give up the longer ranged longbow.

Almost all early artillery pieces were too heavy for field operations and were employed almost exclusively as siege weapons. Known at first as bombards, and later as culverins, cannon, etc., these pieces, like the small arms, were mostly muzzle-loaders. Early efforts at breech-loading proved nearly as dangerous to users as to the foe. The first real successes with gunpowder artillery were achieved by the French during the period 1444-1453 when, in siege operations and defensive battles, they drove the English from France and won the Hundred Years' War. In 1453, also, the Turkish conquest of Constantinople was due almost entirely to their siege artillery train of 70 weapons, including one capsule of firing 1,500-pound stone balls.

The first crude but effective employment of gunpowder weapons as field artillery occurred in the Hussite Wars in the first half of the 15th Century. Borrowing from a technique used by the Russians against Tartar cavalry, John Ziska drew up wagon trains in a circle or a square and gave battle from this impromptu fortification. Ziska added armor to the wagons and put small bombards in the intervals between. The fire of these cannon, combined with the infantrymen's handguns, repulsed the attackers, setting the stage for the counterattack which always won Ziska's battles. But the bombards had to be emplaced on preselected ground in the laager or wagenberg prior to battle and, thus, were not actually mobile field pieces in the modern sense.

True field artillery made a sudden, dramatic appearance in the last decade of the 15th Century when the French, under Charles VIII, rode into Italy with relatively light, cast-bronze cannon mounted on two-wheeled carriages pulled by horses. About this time the French also developed the trunnion, which facilitated mounting the cannon and raising and lowering the weapon's bore for aiming.

The Spanish were the first to succeed in grouping men and gunpowder weapons into a coherent operational formation. Gonsalvo de Cordoba (El Gran Capitan), between 1495 and 1503, instigated this new kind of weapon system. Infantry armed with the arquebus provided a base of fire for maneuver and for offensive action by cavalry and infantry pike columns (organized after the Swiss pattern). The arquebusiers, in turn, were protected either by entrenchments or by pike units or both. This re-confirmed the superiority of disciplined infantry over cavalry and was the genesis of modern concepts of fire and movement with gunpowder weapons. Throughout the following century these concepts were developed further by Cordoba's Spanish successors and other European imitators.

Despite increased range and accuracy, artillery in the 16th Century was considerably less important than small arms, simply because of the weight and clumsiness of the cannon. In addition, there was a lack of standardization, due largely to experimentation. The Spanish, however, led in the employment of artillery, in close coordination with their arquebus and pike infantry unit, which became known as a tercio--a weapon system which was the forerunner of the modern infantry regiment or division. The new tactics which the Spanish pioneered brought about an increasing complexity in the coordination of the defensive-offensive employment of arquebusiers, pikemen, cavalry, artillery and engineers (responsible for field fortifications), all of them dependent upon an efficient and reliable supply of ammunition for the gunpowder weapons.

An important modification in weapons, which enhanced the predominance of infantry firepower, occurred in the second half of the 16th Century when the Spanish introduced the musket. This weapon, which had a long barrel of heavier gauge than the arquebus, was at first too heavy for a man to fire without resting it on a prop (usually a specially-made fork-rest). Later, the musket was improved and reduced in weight, but the matchlock method of firing prevailed until the development of the flintlock in the 17th Century. Then, for more than two centuries, the smooth-bore flintlock musket, exemplified by the British "Brown Bess", was the dominant hand-weapon.

Even before the flintlock, a wheel lock firing mechanism was developed for cavalry pistols. A metal wheel at the side of the priming pan was rotated by a trigger-activated spring, which produced sparks from a piece of iron pyrites. Because the method was complicated and expensive, it found little application in infantry weapons. Wheel lock pistols, however, were extensively employed in a new system of cavalry tactics which combined firepower with mobility and traditional cavalry shock action.

The demise of the long-lived pike started in the early 17th Century (c. 1640) when the French began to plug short daggers with rounded handles into the muzzles of their muskets. Known as "Bayonnettes", from the city where the first of the daggers were made, these weapons had the obvious disadvantage of precluding fire until they were removed. Near the end of the century, a ring-bayonet, clipped into the outside of the musket barrel by a large metal ring, was devised. This was later (1805) refined by the addition of a spring clip that locked the bayonet in place. By the end of the 17th Century, the seemingly irreplaceable pike had almost disappeared.

The hand grenade was also introduced in the 17th Century. Because muskets were inaccurate, attacking troops had to approach within a few yards of the foe before firing; they then charged with the bayonet. This

provided an opportunity for others to run forward and throw shells with burning fuses into enemy ranks. Since this was a risky and difficult task, the tallest and strongest men were chosen to be grenade throwers, or grenadiers. The use of special units for throwing grenades dates back to 1660; eventually, the word "grenadier" became a title of honor for elite forces. Yet because of improvements and changes in hand firearms and tactics, the grenade fell into disuse near the end of the 18th Century, not to return again until the trench warfare of the early 20th Century.

Rise of Professionalism

Coincidentally with the marked increase in importance of gunpowder weapons in the 15th Century, a trend toward military professionalism began to develop in a way not evident since the time of the Roman legions.* By mid-15th Century, following the victories brought about by Joan of Arc, the anarchy created by the disbanded companies of mercenaries in France prompted Charles VII to create 15 (later 20) compagnies d'ordonnance, consisting of 600 men each, as a permanent military establishment to maintain order in France. Charles' advisers, Jean and Gaspard Bureau, established a permanent artillery organization. This creation of a standing army enabled the French to expel the English from the country and to end the Hundred Years' War. Charles' son, Louis XI, continued the military reforms, as did his successor, Charles VIII.

In the 16th Century, the Spanish colunela (column) and later the tercio were further manifestations of the trend toward permanent units, organized usually on a regional basis. Following the Spanish, the French organized permanent units at first called legions, later regiments. Yet throughout most of the 16th Century, the expense of maintaining large, balanced standing armies was so prohibitive that, in wartime, rulers augmented their relatively small permanent forces with mercenary units, usually Swiss pikemen, German landesknechts and reiters, or Italian condottiere companies. Later in the century adequate, permanent units emerged in Europe, notably in Sweden and the Netherlands. In the latter, Maurice of Nassau, under the ever-present Spanish threat, insisted on long-term enlistments and strict discipline. The expansion of Dutch maritime commerce enabled him to pay his soldiers well and punctually. The result was a highly disciplined, homogenous, responsive, professional army, precursor of the professional armies that were to figure prominently in the Thirty Years' War (1618-1648) and in the era of Louis XIV.

*Actually, it had begun in England in the preceding century, when the Plantagenet kings introduced a system of "indenture", whereby their vassals provided standing contingents of troops in return for set payments and allowances. Even though raised and commanded by the nobles, these soldiers owed their allegiance to the king.

The 17th and 18th Centuries

Though Maurice led the way, two captains who emerged during the Thirty Years' War can more properly be credited with bringing professionalism to fruition: Albrecht von Wallenstein of Bohemia and, even more notably, Gustavus Adolphus of Sweden. Wallenstein's reputation (and the plunder that fell to his soldiers) drew willing recruits to his colors; Gustavus capitalized on the rise in nationalism that was born in Sweden toward the end of the 16th Century. And both exploited the religious fervor that gripped Europe at this period.

The roots of the tremendous human suffering and political upheaval that characterized the Thirty Years' War lay not in the lack of professionalism in the armies, but in the haphazard relations of the armies with the states. Poorly organized for war, the states were unable to provide the armies' logistical requirements. War had to support war and, when coupled with religious fervor, plunder, pillage, and devastation ensued. This is a clear demonstration of the fact that weapon systems in any age reflect not only technology but also human and political organization.

In the field of weapons, the main contributions of Gustavus Adolphus were: a shortened pike (the bayonet had not yet appeared); a lighter, more reliable musket, and a paper cartridge containing both powder and the shot to go with it; and standardized, light artillery pieces, capable of being employed rapidly and flexibly not only against fortifications but directly against opposing troops. Gustavus also altered the tactical employment of the old Spanish-type weapon system. Instead of massing his infantry in solid squares, he returned to the concept of the Roman legion, using small squares interspersed with cavalry, thereby gaining flexibility and maneuverability. Gustavus also made his basic formation--the brigade of one to four regiments--a permanent organization under a permanent commander, so that shuffling of units was unnecessary when it came time for battle.

Artillery underwent few changes other than those introduced by Gustavus, primarily because the art of gunmaking already had progressed to the point where the range and power of guns was to change little for more than two centuries. The expensiveness of artillery pieces relative to military budgets had something to do with this, as did the fact that ammunition was too scarce to waste in experimental firing. In following centuries, artillery improvements were mainly limited to mobility, organization, tactics, and field gunnery techniques.

The infantryman with his musket remained the dominant force on the battlefield through the 17th and 18th Centuries. Frederick the Great and other leaders drilled their armies incessantly to speed musket fire (one of Frederick's important innovations was the replacement of the wooden ramrod with one of iron). Although cavalry shock action was often decisive, this was usually only in coordination with infantry

action. The firepower of unbroken infantry simply was too great for horsemen, whose pistol firepower was relatively insignificant and whose most effective weapon was the saber. Nevertheless, the threat of cavalry action contributed to the tendency (partly fathered by custom) to maintain tight-packed infantry formations.

Following the trend established by Gustavus, infantry combat gradually evolved into "linear tactics". In the 17th Century, the slow, cumbersome matchlock musket dictated a relatively deep formation--six men deep, more or less--in order to assure continuous fire. The usual method of fire was by countermarch of files, each man discharging his piece in turn and then dropping back to reload. To permit this, ranks and files had to be fairly open, and the men comprising them were in constant motion, individually. Thus the formation was not rigid but fluid, markedly susceptible to disorder.

With the coming of the bayonet, the need for separate contingents of pikemen and musketeers disappeared; and with the advent of the handier, more dependable flintlock, volley fire replaced individual fire. Hence the old, deep, loose formation by files gradually merged into a dense line, only three or four deep. (The generally accepted formation was two long lines of battalions, formed three or four deep.) Tactical perfection consisted in forming and maintaining perfect lines. Training of troops emphasized precise marching, accurate wheels of elements, and high perfection in the manual of arms and the delivery of volleys. This line of battle was almost as sensitive and easily disordered as the old one, but for a contrary reason--the earlier had been fluid; the new line was brittle.

Frederick the Great's incessant drill, iron discipline, and imaginative inventiveness made his infantry predominant, but Frederick had a profound effect on artillery as well. Using standardized, improved, light pieces, he eliminated the civilian contractors who had normally wheeled artillery into position. Instead, he used soldier-gunners, who were mounted on horses and were able to move rapidly. When close to the enemy infantry, Frederick's gunners exchanged solid shot for grape--50 or 60 iron balls, each about an inch in diameter. Grape shot was not new, but Frederick's artillerymen employed it with particularly devastating effect.

In the latter part of the 18th Century, the Inspector General of French Artillery, Jean de Gribeauval, having profited from fighting against Frederick, undertook a complete re-organization of the French family of artillery weapons. Restricting field pieces to four calibers, he made parts as interchangeable as possible, improved gunsights, and introduced "fixed" ammunition--the ball and charge packed into cartridges. For nearly a century, Gribeauval's 12-pounder gun dominated battlefields all over the world.

Also during the latter part of the 18th Century, two independent but related innovations presaged important tactical and organizational changes. In the first place, bitter experience in the French and Indian War taught the British (and French as well) that the tightly packed drill field formations of European combat could not be used in the forested wilderness of America. The British, therefore, developed a new type of highly disciplined light infantry, capable of fighting effectively in open order formations. The new light infantry was effective in European combat as well, though mainly as skirmishers. Other European nations followed the British example. The Germans, for instance, armed these light infantrymen (whom they called jagers) with rifles, rather than the ordinary military musket, which was the principal infantry weapon then used in the English and other armies.

The rifle had been invented in the Alpine regions of Germany and Switzerland several centuries earlier. Because of its great range and accuracy it was regularly used by mountaineer hunters (hence the name jager). But it had never found favor as a military weapon. Its two great advantages were outweighed by several drawbacks: it was a much more expensive, more complicated weapon; it was considerably heavier; it could not readily be adapted to a bayonet; it could not be as readily standardized as the musket; and it took even longer to load. The advantages of range and accuracy seemed relatively unimportant to 18th-century European military men, who relied upon muskets only to provide concentrated, unaimed volley fire as a preliminary to a climactic and decisive bayonet charge. But for light infantrymen, firing individually instead of en masse, the importance of accuracy and range seemed greater to the Germans.

Almost simultaneously, a similar conclusion was being reached by American colonists in conflicts with the Indians, and then in the American Revolution. The rifle had been introduced to America early by Swiss and German immigrants and, by the middle of the 18th Century, had become modified into a longer, lighter weapon, firing a smaller lead pellet than its European prototype. Called the Kentucky Rifle, it was used by mountaineers and woodsmen along the entire western frontier--the Pennsylvania mountains, Virginia's Blue Ridge and beyond, Tennessee, and the Carolinas. These American rifles, individual products of advanced gunsmithing art, were weapons of amazing accuracy, deadly at ranges of 200 yards and more as the British discovered early in the American Revolution.

Though only a relatively small proportion of Americans--and Tories--were armed with the rifle in the Revolution, it was a highly regarded weapon, ideal for light infantry tactics. As adapted and modified in the following century, this weapon was the genesis of a new family of ground force weapon systems and had the greatest effect on tactics since the introduction of gunpowder. But the transition was not made until other influences were brought to bear in a new technological era.

War at Sea

The trend toward sail rather than oar propulsion had been evident in North European waters long before the advent of gunpowder weapons, but it remained for the Battle of the English Channel (1588) to bring to a climax the long years of stagnation in war at sea. At first, the heavy weight of early cannon was inimical to the principle of light, oar-driven galleys and dangerously overloaded the upper decks of sailing vessels, making them susceptible to capsizing. Once the principle of the gun port (first developed in 1501) was widely adopted, and cannon could be placed safely inside sailing war vessels below the center of gravity, the broadside battery became practicable, and a true revolution in naval warfare developed. Long-range guns (culverin--effective range over a mile, and demi-culverin--effective range, 500 yards) completed the revolution, so that gradually war at sea developed different tactics and strategy than war on land.

The English, as early as the time of Henry VIII, recognized the tactical change made possible by broadside guns. Although for a long time boarding was still considered the main aim of battle, the English tended to put more and more emphasis on designing their ships for long-range gunnery. As a result, the fore and aft castles became lower and lower, and the beaks soon disappeared from English galleons. The proportion of big cannon to small guns steadily increased. Rather than waste space with a garrison of marines, or sea soldiers, the English sailor was trained to fight, to man a cannon, and to hoist a sail. The new tactics of long-range gunfire were first used decisively by the English against the Spanish Armada (1588). Though the actual engagements in this running fight were inconclusive, the English ability to avoid hand-to-hand combat while inflicting severe damage with long-range gunfire ushered in a new naval era.

The principal shortcoming of the galleon was that it was largely at the mercy of the vagaries of the wind. This was only partly offset by the fact that these newer, longer ships were more maneuverable than the earlier adaptations of merchant "round" ships and by improved sails and rigging, which enabled vessels to "beat" against the wind.

In the 17th Century, the newest development at sea was the Tartaglia quadrant, which enabled gunners to set the weapon's angle of elevation with reference to the horizon rather than the ship's deck. About the same time, the English introduced the blunderbuss, a short modification of the musket, which fired a big load of buckshot, particularly effective in repelling boarders. Naval tactics became stereotyped: a single line ahead, with ships smashing each other with great guns until so weakened by cannonade that one could be taken by boarding. Until well past mid-18th Century, admirals who permitted deviation from the rigid, line-ahead formation were likely to be court-martialed and the punishment in the British Navy was sometimes death.*

*See Appendix C.

Ship's cannon still were smoothbore muzzle-loaders made of cast bronze or iron; the 32-pounder, a 3-ton gun of about 6-inch caliber, was the biggest a line-of-battle ship could handle in its broadside. Late in the 18th Century, the British introduced a new piece, the "cannonade", a short, squatty gun with smashing power at close range far superior to normal armament. It was relatively light and easy to manufacture, but had shortcomings in range. Gun carriages were heavy timber frames riding on four small wheels. After firing, the gun rolled back on its own recoil until stopped by heavy breeching ropes. Late in the century, the addition of block and tackle purchases permitted improved but limited traverse of the guns, thus enabling them to be aimed without "aiming the ship". Naval gunnery was of two schools: the British directed their fire so as to hull the enemy, smash in her oaken sides and sink her; the French aimed for the enemy's tophammer to immobilize her by shooting away masts and rigging.

By the end of the 18th Century the ship of the line had become an immense wooden machine, weighing about 3,000 tons, and measuring nearly 200 feet in length, about the limit for wooden construction. She might carry up to a hundred guns.

By the 18th Century, also, there had been a few navigational innovations, such as the marine chronometer and the sextant. And improved flag signal codes were gradually developed, whereby commanders could maintain control and issue orders until the moment the battle was joined.

The Transition to Technology

The first stirrings of the Industrial Revolution were evident about the time of the French Revolution; in fact, each of these Revolutions influenced the other. New machinery, the first crude uses of steam for operating machines, dawning concepts of mass production and interchangeable parts; all were important in permitting the levee en masse, which was largely responsible for the early critical successes of the raw, undisciplined French militiamen against the professional soldiery of Europe. In subsequent decades, the amazing technological changes of the Industrial Revolution--based primarily on steam and steel--were also applied with revolutionary effects to military weapons and operational procedures. And affecting this new warfare, too, was the impact of one of the greatest of all military geniuses: Napoleon Bonaparte.

Napoleon, an artilleryman himself, put new emphasis on use of the artillery piece. "Le feu est tout", he said. Massed artillery was concentrated on a predetermined weak point in the enemy line, whereupon dense columns of infantry forced a penetration. Napoleon also made wide and effective use of the recently developed "Light companies" as skirmishers, who preceded the main formations, firing from cover to harass the enemy and ferret out his weak points. But Napoleon's innovations were more strategical than tactical; he merely made amazingly better use of the new weapons and tactics developed by his immediate

predecessors. Tactically, his victories were a result of the highest refinement of 18th-century methods; strategically, his concept and employment of the nation in arms, and of the coordinated employment of the largest armies ever seen in Europe, ushered in a new era of warfare.

The echoes of Waterloo had scarcely stilled when new inventions and innovations transformed the face of war in a spectacular new century. One of the first innovations was the percussion cap, which came into general use about 1820, followed before mid-century by the cylindro-conoidal or expanding bullet. The latter was a French innovation named the "Minie ball" after its inventor. By expanding to seal the propelling gases (which resulted in increased velocity and range), permitting standardization, and facilitating loading, it, for the first time, made rifling--and thus accuracy--truly practicable in a common military weapon. Mass production of small arms, introduced by Eli Whitney in America as the 18th Century closed, also provided practicality. The turn of the century saw the introduction of the rocket into Western warfare. But its vogue was brief; its notorious inaccuracy served to eliminate it from arsenals.

The Crimean War--despite the abysmal military leadership on both sides--was in many respects a watershed between the pretechnological and technological ages in warfare. Here, for the first time, were emphasized the tremendous new factors other than technological that were to influence warfare throughout the 19th Century and until the present. The absolute monarchial governments of the 18th Century, for example, had given way to popular and, relatively, responsible governments. (Reports from war correspondents by cable and telegraph, describing the suffering of British troops in the Crimea, brought the downfall of a British government.) Other factors, too, were having their inevitable impact: industrialism and urbanism, improved agriculture, higher standards of public education at secondary and higher levels, and increasing specialization and professionalism of the officer class, as contrasted with the aristocratic ignoramuses of the 18th-century officer caste.

A combination of all these factors, along with weapons innovations, dictated a need for new forms of military organization; the British still used their "thin red line"; the French, the skirmishers and the column, not too different from those of Napoleon; the Russians, deep, heavy masses inhibiting firepower. Although the Crimean War failed to provide new forms, it did point up the directions in which warfare now had to move.

In some respects, Europeans took longer to discern these directions than Americans. The Civil War became the real proving ground for a host of new and modified weapons, whose increased lethality, combined with the tremendous masses of men wielding them, made clear the necessity

for changes. Divisions, corps, and separate armies--all presaged in the Napoleonic era-- became the norm. Divisions comprised both infantry and artillery, although additional artillery was concentrated at corps level. Fire and movement became the method by which the divisions advanced. Dispersion was essential, putting a premium on leadership at lower levels and on the courage and ingenuity of the individual soldier himself. The greater firepower made cavalry charges suicidal, so that cavalry was employed almost entirely on raiding, screening, and reconnaissance missions.

The two major technological developments in the 19th Century which were absolutely essential to many significant mechanical innovations were steam and steel. Although steam had been harnessed in the previous century, its real use for motive power on land and sea came during the first three decades of the 19th Century. Steel is definitely a mid-19th Century development. These twin giants of the Industrial Revolution played a significant role in warfare for the first time in the Civil War. Among other technological developments in the military field during that war were an effective breechloading rifle; repeating rifles and pistols; metallic cartridges and improved powder; and breechloading and rifled artillery, which fired deadly explosive shells and improved shrapnel (the latter a sophisticated form of grape shot invented early in the century by an English artilleryman). Railroads greatly expanded the size of the theater of war and gave new meaning to maneuverability and logistics. The telegraph transformed communications down to division level. Military observation balloons (first used at the end of the 18th Century in France) were employed for aerial reconnaissance. The spade developed into a weapon in its own right, as both armies were forced to entrench for protection.

While the Europeans were slower to adapt to the changes in warfare, they were nonetheless introducing new departures. The Prussians employed the breechloading "needle gun" infantry rifle (prototype of modern bolt-action small arms) in the Seven Weeks' War of 1866, although that weapon had been developed a score of years earlier. The French employed an even better, longer range, bolt-action infantry rifle--the celebrated chassepot - - in the Franco-Prussian War. The bayonet persisted in theory, but was little used in practice; the range and accuracy of new weapons made it difficult for infantrymen to get close enough for hand-to-hand combat.

The Prussians, in 1870, demonstrated again the military utility of the railroad, especially in a strategic sense (rapid mobilization and concentration). Artillery recoil was at last conquered, first by an ingenious trough and spring mechanism, later through hydropneumatic absorption. Solid shot for artillery pieces disappeared with the introduction of armor-piercing rounds and lighter walled, antipersonnel explosive projectiles. Shells came equipped with either time or impact fuses. And by 1870 the Prussians adopted the steel artillery piece. Concrete and steel began to revolutionize the art of fortifications.

At the end of the century smokeless powder came into use, notably in the Boer War. (Here it was at last made brutally clear to the British that compact lines, no matter how well disciplined, had no place on a battlefield peopled on the opposing side by sharp-shooting, dispersed riflemen.) The Americans, surprisingly in light of their pioneering efforts in the Civil War, were slow to adopt smokeless powder.

The most portentous land weapon of all was the machine gun. Since the appearance of gunpowder, more than one inventor had tried his hand at developing an automatic, repeating gun. In the process, some strange instruments of warfare were produced such as the orgues or organs of the 17th Century and the ill-used and short-lived French mitrailleuse of the War of 1870. The more practical Gatling gun saw some use in the American Civil War, in the Spanish-American War, and in British colonial wars. But the first true machine gun, as the weapon was finally developed, was produced by an American who became a naturalized Britisher, Hiram Maxim. In 1885 he devised a gun that used its own recoil energy to load itself, fire, and eject its own empty shells; the gunner only aimed and squeezed the trigger. Subsequently, John Browning, an American, refined the piece, using gas pressure rather than recoil for operating power. By the end of the century, all major armies possessed machine guns, but they still had not divined the tremendous impact the weapon would have on the nature of war.

The Revolution at Sea

The revolution in warfare extended to the sea as well. Early in the century most navies (particularly the British) looked askance at steam, because of the vulnerability of the paddlewheel to enemy fire and because of the way steam tethered the ships to coaling stations. But experience in the Crimean War wrote an end to sail. The propelling screw solved the first problem, acquisition of colonies the second. As late as 1870 ships still were being built with auxiliary sail power but, from approximately 1845 on, no new warship without steam could reasonably be built.

In combat, the line ahead (ships in single file) was still the normal tactical formation, and broadside fire was optimum. But the tacticians were toying with "crossing the T", a new version of raking, in which by superior speed a fleet in single file could concentrate its fire upon the lead ships of the slower line. Late in the 19th Century the speedy torpedo boat, and still later the torpedo-boat destroyer, assumed the important function of disrupting the hostile line by sinking individual ships. The new tactics were greatly facilitated by the new freedom from dependence on the direction and velocity of the wind.

With the invention of the hot-blast furnace in 1834, a second, concurrent revolution swept the sea as iron competed with wood for ship building. The French constructed armored warships in 1858, closely followed by the British; and the duel between the Merrimack and Monitor

in the U.S. Civil War speeded the conversion to iron and armor plate in Europe. The Monitor also introduced the revolving turret to naval ship building, heralding the advent of "all-round" fire instead of the broadside. And in 1862, the development of the open-hearth process for making steel further improved ship building and naval armor. Another improvement in warships came before the end of the century with invention of the reaction steam turbine, which abandoned the energy-wasting reciprocating piston. Torpedoes, too, at first as stationary mines and later as automotive torpedoes, were introduced. But even though various efforts were made to construct reliable submarines, serious development of underwater craft awaited the advent of the gasoline engine.

Throughout the latter half of the century, there was a race in the development of guns and armor. The shell gun, dramatically employed by the Russians in the naval battle against the Turks at Sinope in 1853, led the way. Steel, rifling, breechloading, controlled recoil, and slow-burning powders spelled increased power and serviceability for weapons. Every advance in the gun stimulated in turn a corresponding advance in the strength and thickness of the ship's armor. In the two decades from 1860 to 1880 armor increased from 4 inches to 24 inches at the water line, a thickness not later surpassed. Yet smaller vessels obviously could not compete in such a race, and armor was restricted to the larger warships, while smaller vessels like the fragile torpedo boat and the torpedo-boat destroyer sought security in speed and in the compartmentation of their hulls. About 1885, the major navies of the world adopted the modern categories of battleship and cruiser. The period of transition and blind experiment which had lasted since the 1850's came to an end, though there was no slackening in the pace of progress.

The Age of Technology

The 19th Century was the laboratory; the first quarter of the 20th Century was the proving ground. The Russo-Japanese War of 1904-1905 should have shown what was in store, though the trend was clear in the American Civil War. But military leaders failed to grasp the true significance of the fantastically increased firepower provided by the new weapons. Neither did they appreciate fully the impact that industrialization, and its concomitant release of the masses for war service, would have on war. The result was a shocking holocaust in World War I.

Land Warfare in World War I

There were, at first, few truly new weapons. While the machine gun "locked" the battlefield, artillery did most of the killing. The French 75mm gun (an artillery piece introduced at the close of the century) and its German 76mm counterpart were predominant on both sides, while special German siege guns quickly destroyed the faith the Allies had put in the defensive capability of the Belgian forts. Improved fire control techniques

and field telephones enabled the artillery to deliver its fire--shrapnel, impact-and-time-fused shells--from defilade positions. The short-delay French fuze, fragmenting thin-skinned projectiles, began to supersede shrapnel. Firing from map coordinates became an exact science, and indirect counterbattery fire assumed increasing importance.

The basic organization for delivering the increased firepower was the infantry division, on each side composed of two brigades of two regiments each of infantry, plus supporting regiments of artillery. At the corps level, additional artillery was present. Corps were grouped under armies and armies under army groups. Mammoth logistical organizations were essential behind the lines to keep the masses of men supplied with food, ammunition, and equipment.

Horrible and unexpected casualties from artillery and machine guns brought the reeling opponents to a stalemate; the spade and barbed wire took over, and with them close-combat weapons--the hand grenade, rifle grenade, submachine gun, automatic rifle, short-range mortar, pistol, and revolver. The machine gun continued to be the dominant infantry weapon in the field fortifications extending from the North Sea to the Alps. Every effort to employ the Napoleonic principle of "Le feu est tout" to achieve a penetration failed. It was possible to blast a gap in a section of the opposing trenches, but neither side could find a way to widen the gap effectively so as to exploit and pursue. Cavalry, the traditional arm of exploitation, was useless against the firepower available. Thus a gap at great cost was quickly plugged by more entrenchment.

Out of the effort to eliminate the stalemate, scientists and innovators came up with two dramatic new weapons: poison gas and the tank; but in neither case did the side that used them first realize the full potentialities of the new weapons before the opposing side found antidotes. The quick development of gas masks soon reduced gas to a weapon of harassment. And the tank, revolutionary as it proved to be later, was too primitive mechanically, and was first employed in numbers too small, to achieve much success. With speed of only three to four miles per hour, it was in effect no more than a mobile armored machine gun nest.

The internal combustion engine, which made the tank possible, advanced the other most portentous developments of World War I: the truck and the airplane. Gallieni's use of Paris taxicabs to send reinforcements for the First Battle of the Marne (actually a very small thing in itself) dramatically demonstrated the potentialities of motor transport for maneuver, and the truck route, Voie Sacree, succoring Verdun, did the same for supply.

A New Dimension: Air Warfare

The airplane was, at first, no more than a reconnaissance vehicle, but as its value for reconnaissance increased, it became important for each side to destroy planes used by the other. Speeds increased; and machine guns were added, creating the fighter plane. In 1915, a synchronizing gear was adopted which allowed a fixed machine gun to fire through a revolving propeller without striking it. Gradually, pilots and planes were organized into squadrons for administrative and tactical control.

At the beginning of the war, there was aerial bombing by German dirigibles or Zeppelins, which were named for an inventive German who had observed Civil War observation balloons from the White House lawn. But the Zeppelins fell before the bullets of the plane; and larger, better planes took over the bombing assignments. Before the war was over, the British had developed a bomber capable of transporting a 1,650-pound bomb (though true strategic aerial bombardment came later). American General "Billy" Mitchell devised a plan for an airborne parachute attack, but the war ended before it could be attempted.

Naval Warfare in World War I

As with the truck, the tank, and the plane, the gasoline engine also led to development of the submarine; the problem of clouds of smoke and fumes such engines released was solved by using electric power to propel the underwater craft when submerged. The Germans excelled with Diesel-powered U-boats (Unterseeboote) which, armed with torpedoes and equipped with the gyroscopic compass, nearly won the war by blockading the British Isles. Eventually, they were defeated by aerial surveillance, Q-boats (armed vessels disguised as innocent merchantmen), depth charges, and--above all--the convoy system. Indirectly, the submarine lost the war for the Germans, for indiscriminate sinkings by U-boats eventually involved the United States in war--and the balance of power was tipped.

On the ocean's surface, before hostilities opened, Britain's Dreadnought, in 1906, rendered obsolete all previously constructed battleships. Combining heavy armor, immense weight of metal hurled by an homogenous group of turreted guns of up to 15-inch caliber, and all-round fire capabilities, ships of the dreadnought class prompted an armament race. As a result, naval designers, searching to combine fire-power and mobility, designed the battle cruiser; gunned to near-equality with the dreadnought the battle cruiser sacrificed a heavy protected armor belt in order to achieve greater speed.

The Germans augmented their submarines with surface raiders, but aerial surveillance and the speed of the wireless telegraph early overcame any

advantage of speed that the raiders possessed. German mines, however, were a menace throughout the war, particularly in such restricted waters as the English Channel.

When World War I ended, the most revolutionary naval development remained the submarine, whose menace was never completely neutralized.

Efforts to Break the Land Stalemate

Similarly, on land, there were inconclusive solutions to the stalemate induced by the immense new firepower. Although The English tanks had proved relatively successful at the Somme (1915) and at Amiens (1917) they had been unable to exploit initial breakthroughs. The Germans had come closer to a tactical solution with their Hutier Tactics, named after the general who first employed the new method against the Russians in the fall of 1917.

The Hutier Tactics involved no startling new method or weapon; this was merely the application of time-proven, basic principles to the new conditions of war. Surprise was the keynote, obtained partly by moving units secretly to attacking positions and partly by reducing preassault bombardments from several hours to a few short furious minutes; the infantry then moved against the hostile entrenchments behind a rolling artillery barrage. Gaps or weak points in the defenses were exploited by infiltration through "soft-spots" by small infantry battle groups which used the light machine gun as the principal attack weapon. Strong points were bypassed, then later mopped up by reserves.

In a series of great offensives in early 1918, the Germans employed this new tactical system with deadly effect in the West. In the first of these, the British front was shattered and the Germans broke through completely. For the first time since 1918, there was open warfare on the Western Front. But eventually, after a series of spectacular successes, the offensive ground to a halt; this was as much due to inability to keep up momentum as it was to the desperate, gallant, defensive efforts of the British. Despite the tactical efficiency of the new infantry tactics, there were serious operational and strategic deficiencies in the system. Four years of warfare had obliterated all roads in the wide battle zone; trenches and overlapping shell holes made this region impassable for wheeled vehicles. The German assault waves simply outran their artillery, their supplies, and their reinforcements. The same thing happened on subsequent German drives, until Ludendorff's army was "bled white". Then the Allies, reinforced by fresh American troops, counter-attacked.

Beginning in August 1918, the Allies counter-attacked in the final, victorious campaigns of the war; the naval blockade and a collapse of morale on the German home front contributed to victory almost as much as American and British successes on the battlefield. For all the array of weapons that the age of technology had produced, no truly effective modern land weapon system had been found. But the Germans had come close with their Hutier Tactics--and so had the British with their tanks.

Land Warfare in World War II

With the benefit of a dress rehearsal in the Spanish Civil War (1936-1939), by the outset of World War II German military leaders solved the weapon system impasse by devising a combined arms team—not unlike a modern version of the Roman legion—made up of planes, tanks, and mobile infantry and artillery. The new tactical doctrines, which emerged from the German study of their failure in 1918, were introduced with astonishing success as blitzkrieg in Poland (1939). The success was repeated in 1940 to break the western Allies on the Meuse. In both cases, heavy armored divisions, assisted by infantry, achieved the penetration and made the exploitation. But as the war progressed, the role of shock passed again to infantry and artillery firepower, while armor took over cavalry's old exploitation role.

The combined arms concept was not confined to the heavy armored divisions. It was present in the infantry divisions as well, for in addition to infantry and artillery, tank and tank-destroyer battalions were almost always present with infantry divisions. Two infantry and one armored division normally made up a corps, and there were also special armored and airborne corps. Several corps made up an army and, as in World War I, two or more armies an army group. But the basic land weapon system remained the division, though special combined arms elements of a division were employed for special operations. These usually were called task forces or, in the case of amphibious operations, battalion landing teams.

Most of the infantry weapons were improved versions of those introduced in World War I: hand grenades, rifles (the American Army used a semi-automatic model), mortars, machine guns and machine pistols, sub-machine guns, and automatic rifles. Artillery pieces, too, were improved versions of World War I weapons though, in the American Army, the 105mm howitzer assumed the workhorse role played earlier by the French 75mm gun. But the new tanks bore only incidental resemblance to their ancestors. Though some light tanks were used, most were in the medium or heavy class, weighing 30 to 60-or-so tons, and mounting not only machine guns but high-velocity 88mm and 90mm cannon. Speeds averaged around 30 miles an hour, and a gyrostabilizer and power traverse provided flexibility and speed in firing. Some tanks were equipped as flame throwers, others for amphibious operations.

There were also dramatic new developments in infantry and artillery weapons and equipment. Rocket launchers that worked on the Munro Effect (or shaped-charge) principle for penetrating armor put an effective antitank weapon in the hands of the individual soldier. Telephones, both battery and sound powered; portable and vehicular radios, some employing the principle of frequency modulation; all enabled rapid communications down to the squad level. Before the war was over, infrared devices to enable the soldier to see at night were tried; powerful recoilless rifles firing 57mm and 75mm shells were introduced; antipersonnel and antitank mines were employed; and portable flame throwers aided close-in fighting.

By the end of the war almost all artillery was either truck drawn or self-propelled, including a powerful new family of antitank guns. Some artillery was air portable; other pieces could be broken down and transported by pack animals through difficult terrain (the British had employed the same principle with their "screw gun" in mid-19th Century). Anti-aircraft guns, equipped with electronic fire control devices, came in various calibers. A new family of shells was created to exploit a proximity or proximity fuse with a built-in triggering device to explode it above the target without the necessity of a time fuse. Though poison gas shells were plentiful, an unwritten mutual agreement prevented either side from employing poisonous chemical weapons. Shrapnel entirely disappeared and was replaced by the jagged fragments of the explosive shells themselves. American artillery proved far superior to all other artillery in the war, not because of better weapons, but because of a more imaginative and flexible system of fire control, which utilized communications facilities to concentrate great masses of artillery fire on any target within range.

Rockets returned to national arsenals, often fired electrically from a battery of tubes sometimes mounted on tanks. Balloons, too, were used, but anchored to heavy cables to protect cities and invasion beaches from low-flying aircraft. A swift-moving, dependable family of motor vehicles aided maneuver and supply. They ranged from small reconnaissance and general purpose vehicles to great transport trucks. Lightly armored, half-tracked vehicles transported infantrymen in the armored divisions, and an amphibious truck called the "Duck" (DUKW) proved its worth in sea-to-shore operations.

Speed and increased dispersion largely outmoded the elaborate field fortifications of the U.S. Civil War and World War I variety. In place of the trench, soldiers dug individual or two-man slit trenches and "foxholes". When concrete and steel were used in the massive fortifications of the Maginot and Siegfried Lines and a new line of Belgian forts, the power of artillery rendered them relatively useless, as were the fortifications of World War I.

Air Warfare

The airplane, like the tank, bore only slight resemblance to the World War I model. There were frail, single-engine liaison craft that acted as eyes for the artillery; there were fast, highly maneuverable fighters and fighter-bombers; and before the war was over, jet-propelled fighters. There were big cargo planes that brought to fruition "Billy" Mitchell's dream of airborne assault by parachute; and big, but fragile, towed gliders carried men, artillery, small vehicles, and supplies. And there were bombers of various sizes, including those that could transport 5,000-pound bombs at a range of well over 5,000 miles. (Bombs came in various models, including fragmentation, demolition, and incendiary, the latter including some with an inflammable liquid not unlike Greek fire.) Planes were organized by squadrons, commands, groups, and air forces.

The Germans introduced a new mode of warfare with their V-weapotis: one pilotless aircraft, the other a supersonic rocket which was the fore-runner of the ballistic missile.

Perhaps one of the most important World War II developments was radar (radio detection and ranging), which was adapted to ships, airplanes, antiaircraft guns, and submarines. Radar was invaluable for detecting the approach of enemy planes; and it enabled operators far in the rear to "talk" bombers onto their targets through cloud and overcast.

Naval Warfare

At sea, the big battleship became obsolete, unable by itself to cope with air attack, but still marginally useful as a floating gun platform. The aircraft carrier became the new capital ship. To facilitate amphibious landings, a new family of naval craft was developed, some designed to carry infantry, others tanks, and others supplies. Improved torpedoes, using pure oxygen under compression instead of air for combustion of the fuel, eliminated much of the telltale wake characteristic of earlier versions.

Against Germany the principal aspect of the war at sea was once more a struggle against the submarine. Again Britain was threatened with starvation, this time by a new, deadly U-Boat tactic of traveling and attacking in "wolf packs". By the end of the war, German underwater craft were equipped with radar and, later, with Schnorke¹ "breathing" devices. Sonar (sound navigation and ranging), an adaptation of radar, and improved depth charges proved important measures in combating the submarine. But the old methods of convoys and aerial surveillance were the major factors in defeating the German undersea menace.

On land, sea, and in the air, the age of technology had produced an incredible array of new weapons and improvements in weapons but the ultimate achievement was reserved for the final days of the war. On August 6, 1945, an American plane dropped an atomic bomb on Hiroshima. This was the genesis of a cycle of weapons and weapon systems development still in process, with consequences not yet calculable.

Nevertheless, to those who are concerned with the means and procedures for command and control of these new weapon systems, there is much in the history of past weapons developments, as briefly suggested in these pages, which will permit an educated projection of current trends and some estimation of future alternative possibilities.

From what we have noted in the course of weapons history, for instance, it is possible to infer that dramatic military successes of the past have been due less to the introduction of new weapons than they have upon the imaginative development of a doctrine of command and control which has permitted improved use of previously unsuspected--or inadequately exploited

aspects of the weapons' potentialities. For instance, we have noted that Genghis Khan and his successors conquered most of the known world in a few decades with weapons that had been in existence for centuries. The Mongol victories were due to novel and relatively sophisticated methods of employment of these weapons. Similarly Edward III at Crecy owed his success to the way in which he integrated the long-bow--an old and relatively simple infantry missile weapon--into a coordinated tactical weapon system, while his opponents, who had the equally powerful and more sophisticated crossbow available in adequate quantities, had no thought of a tactical revolution. Another case in point is the way in which the Swiss, after an interval of seventeen centuries, were able to employ pikes in a tactical system comparable in concept and in success to that of the ancient Macedonians.

Accordingly, in any future effort to analyze the potentialities of the new weapons, and the command and control systems for employing them, it would appear fruitful to investigate to a degree not possible in this exploratory survey, the circumstances in history when important weapons of the past were introduced. It would be useful to ascertain the relative significance of the innovations themselves, as opposed to the doctrine, and the control systems, for employment of them. Was it, for instance, the perfected tank at the beginning of World War II, or rather its use in combination with other means at the disposal of the Germans, that gave blitzkrieg its overwhelming effect? And why didn't the Allies use comparable weapons with comparable success?

One approach to the investigation suggested in the preceding paragraph might be a careful analysis of each of the major periods of revolution in warfare, for the purpose of shedding light on why one society was able to adapt a new weapon to a successful method of warfare while another was not able to do so. Related to this is the question raised by evidence that one society was able to develop imaginative leaders who could shape command and control aspects of a new situation into successful application, while an equally advanced society was unable to do so. Were there some special geographic, economic, political, social, or other factors involved? In sum, investigation should seek to isolate at least some of the historical factors that motivated any successful shift from one weapon, or system, to another one and the extent to which doctrine contributed to the success.

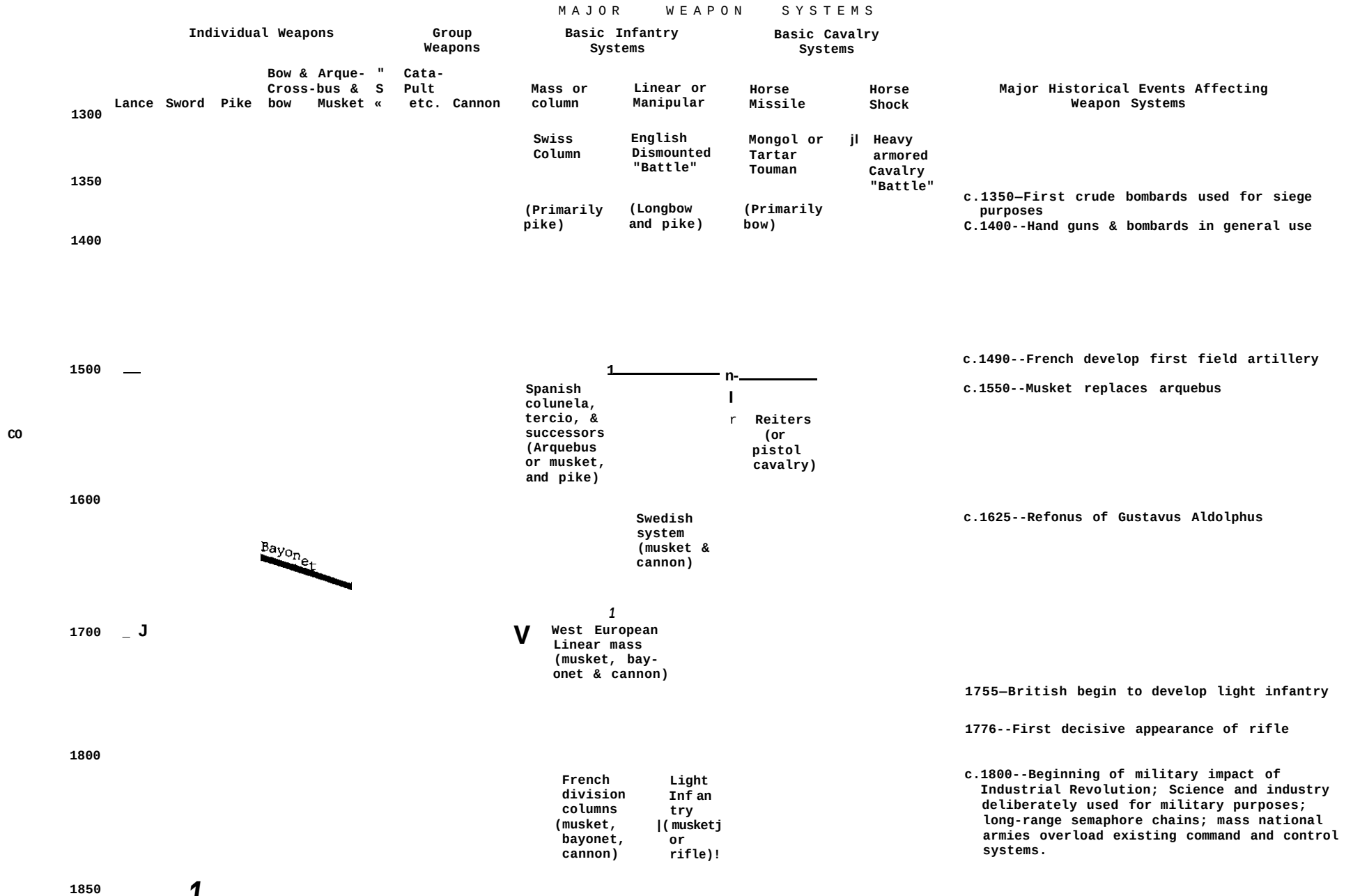
LAND-BASED WEAPONS AND WEAPON SYSTEMS: PRE-GUNPOWDER ERA (to 1350 AD)

• A J Ø R W K A P Ø 1 " ' ? ? r

	Individual Weapons					Group Wpns. Catapult etc. Chariot		Basic Infantry Systems Mass or column		Basic Cavalry Systems Horse Missile Horse Shock		Major Historical Events Affecting Weapons and Weapon Systems	
	Sword	Javelin	Axe	Pike	Bow								
Pre- History										Scythian Horse Archer Hordes (Bow)	'war Chariot Systems	1500-1000 BC - Horsed invaders and iron weapons over- throw ancient military systems	
500 BC								Greek Phalanx (Pike)				490 BC - Battle of Marathon; supremacy of in- fantry phalanx	
300 BC								Macedonian Phalanx (pike)	• Roman Legion (sword & javelin) m'			197,168 BC Battles of Cynoscephylae & Pydna; legion supreme over phalanx	
100 BC - "												27 BC Augustan legion, fixed frontier fortifications	
100 AD — •									Later Legion	H - T		c.100 AD - Introduction of stirrup permits cavalry lance shock	
300 AD --									(sword, pike & onager)			378 AD Battle of Adrianople; defeat of legion; ascendancy of cavalry	
500 AD —								Frank foot masses (sword & axe) .	"II	Roman Cataphract	Teutonic Horse Masses -		
700 AD - •										Byzantine Cataphract & Turma (bow & lance)	West Euro- pean massed cavalry		
900 AD													
1100 AD - •											"Battle" (lance, sword & axe)	e.1000 - Introduction of crossbow 1071 - Battle of Manzikert; decline of Byzantine cataphract c.1100 - Invention of trebuchet c.1200 - Longbow adopted in England	
1300 AD —													
1350 AD —								Swiss phalangial columns (pike)	"Battle" (long-bow & pike)	English dis- tinted H I	Mongol Touman- U (probably bow)	1346 Battle of Crecy; longbow defeats feudal cavalry; beginning of infantry ascen- dency; possible first appearance of gun- powder in warfare	

Chart 1

LAND-BASED WEAPONS AND WEAPON SYSTEMS; EARLY MODERN ERA (1350-1850)*



*Period of Dynastic National States; Armies under monarchs or their immediate agents.

LAND-BASED WEAPONS AND WEAPON SYSTEMS; THE INDUSTRIAL ERA (1800-1950)

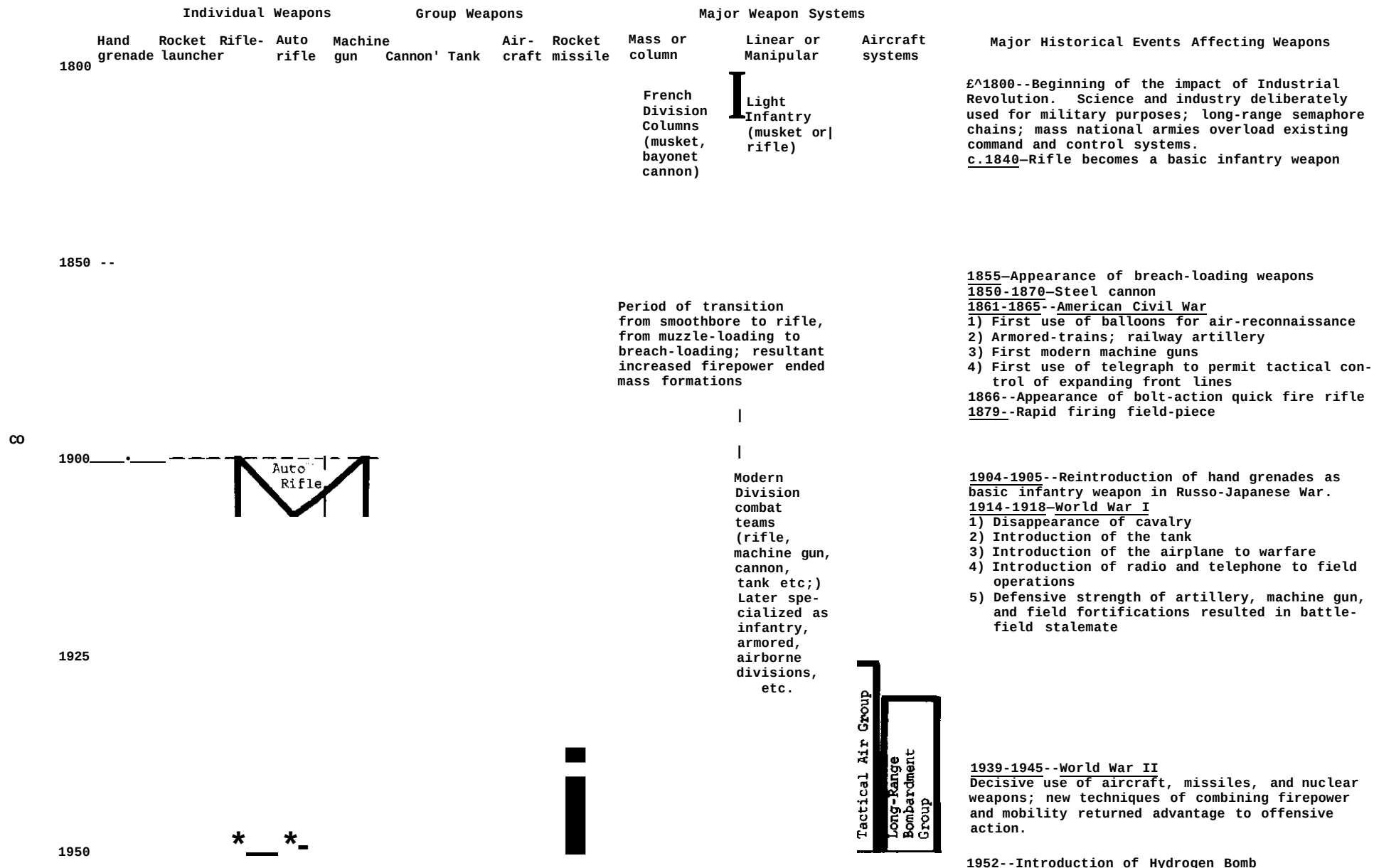
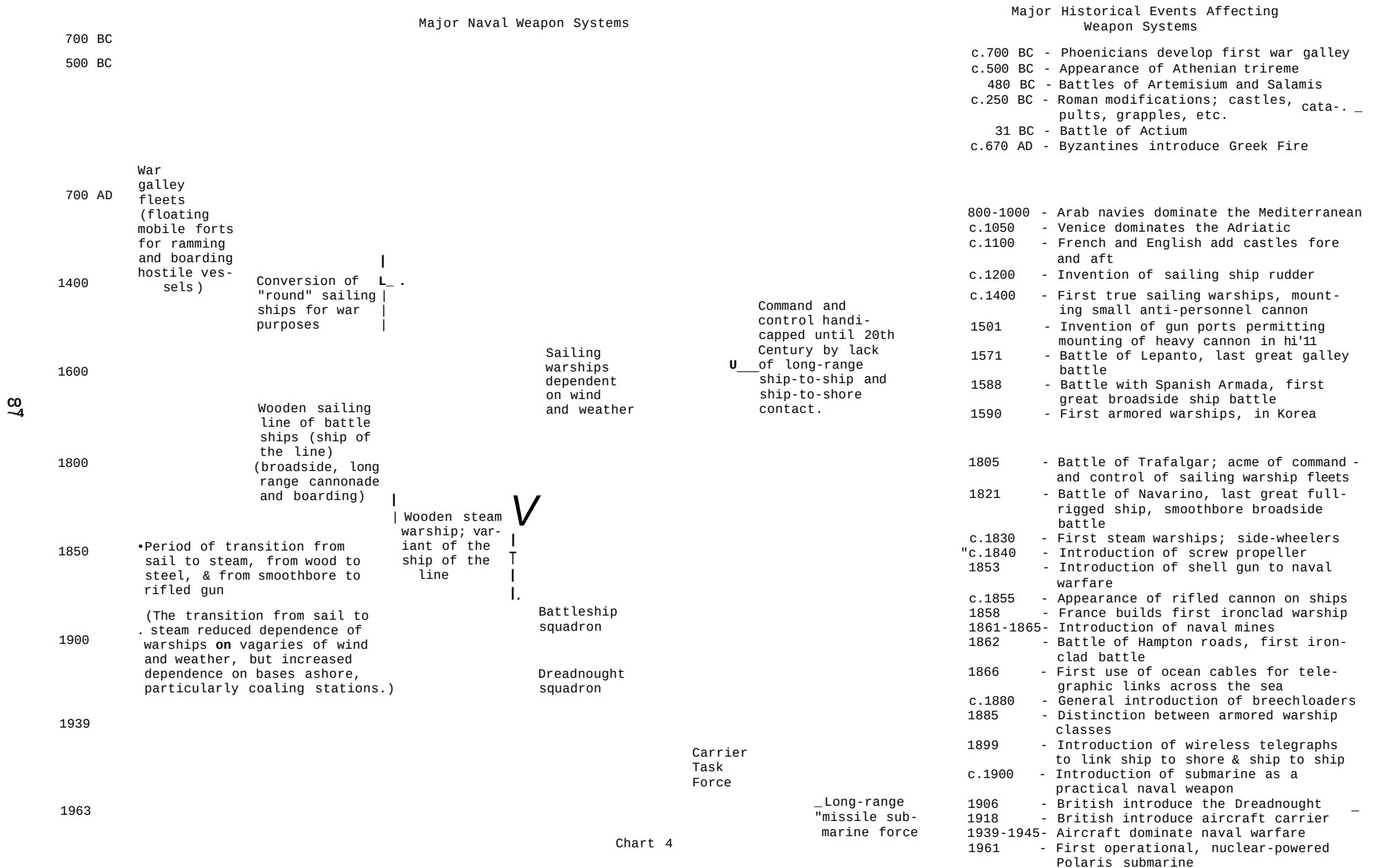


Chart 3

SEA-BASED WEAPON SYSTEMS IN HISTORY



APPENDIX C

A SURVEY OF COMMAND AND CONTROL IN HISTORY

Introduction

Leadership is the most important factor in military success. It manifests itself in many ways. The true leader harnesses, develops, and utilizes to the fullest extent all available resources in men and materiel. He prepares for battle with wisdom. He exercises tactical skill and ingenuity on the battlefield. He inspires men to feats of exceptional courage and endurance. And, finally, he employs determination and perseverance in the face of adversity. But fundamental to the manifestation of these qualities is the ability to communicate decisions clearly and accurately to subordinates. Intellectual abilities, skill, courage, and the charismatic qualities of a leader are worthless without the means to both issue commands and to control fighting men.

Leadership, and the need for a system of command and control to implement it, are unquestionably as important in today's era of advanced technology as they were in the days of pretechnological warfare. But recent developments may have radically altered the scope of leadership. Faced with adapting methods of warfare and of command and control to technological and environmental change, man himself has remained a constant factor throughout military history; his capability to absorb information, and to react to it, has not changed. Yet now, new automated and computerized equipment has provided him with tools which, to some degree, have reduced the effects of his own inherent human limitations. Other technological innovations have increased the factors of space, numbers, and destructive powers, while radically reducing permissible reaction time.

These developments pose vital questions for military and civilian planners who must continually strive to assure that men and weapons are fully responsive to leadership through adequate command and control. Consider these questions: Has increasing exclusivity in access to information and technology concentrated decision-making at the highest echelons? Will the consequent vacuum in information on the operational levels create a malaise affecting responsiveness, and the exercise of initiative in times of crisis and emergency? or, Have revolutionary new developments in warfare created basically different requirements in modern command and control systems?

The phenomenon of the appearance of revolutionary new weapons and consequently, the establishment of fundamentally different methods of exercising command and control has been continuous throughout the course of history, though it is questionable, indeed, whether past turning

points in warfare have been as significant in degree as those which are currently taking place. Nevertheless, a survey of history can surely provide a basis for ascertaining the extent to which the modern revolution in warfare may be comparable to those of the past. Such a survey will, at the very least, reveal trends from which conclusions may be drawn.

Land Warfare Before the French Revolution

From Antiquity through the Middle Ages

During the first 2,000 years of semiorganized warfare, individual leaders commanded irregular groups of fighters by personal force or example and directed them by voice or hand signals. Not until about 1500 B.C. did military organization emerge, generally as simple groups of men who were armed or mounted alike. For nearly another thousand years, military units remained largely undisciplined, poorly trained, and, once committed to battle, generally uncontrolled in the melee of close combat.

In the 16th Century B.C., the growing recognition by Cyrus and Darius of structure and linkage as essential elements of command and control made possible the far-reaching successes of Persia's great military conquerors. The essence of Darius' system lay in the control he established over the empire by forming provinces or satrapies, each garrisoned by soldiers who were commanded by a general directly responsible to the emperor. The provinces were effectively linked to the emperor by an efficient system of mounted messengers, operating over an excellent road net. Capable subordinate commanders were developed by this system, making it usually unnecessary for Darius himself to take the field. When Darius personally commanded major operations, subordinate forces operated semi-independently on auxiliary missions, sometimes by sea. And preceding each major campaign, preliminary expeditions were dispatched to gather intelligence information, which strongly influenced Darius' strategic battle plans.

These innovations, plus an engineering prowess capable of bridging the Bosphorus, opened to Darius a wide field for strategic decision. On the battlefield, however, the only crucial decision to be made remained that of when and where to commit the Persian cavalry for maximum shock effect.

By the 6th Century B.C., Greek military leaders applied discipline and training to battle tactics and developed the Greek phalanx--the first important tactical formation in history. Consisting of a solid mass of heavy infantry capable of preserving a rigid organization throughout a series of limited but highly effective maneuvers, the phalanx, despite primitive tactical linkage mechanisms, gave commanders relatively firm control over their men. But decision still remained more a strategic

and pre-battle process than a battlefield prerogative; there was little change in the basic ingredients of success.

Innovations by Philip and Alexander in providing support for the phalanx with cavalry, archers, field artillery, engineering, and a fairly sophisticated logistical system added power and provided greater range for strategic decision. But a basic inflexibility of formation, partially due to the problem of signals communication, made it difficult for a commander to influence the fighting once the clash had come. Voice commands or trumpet signals, heard by men marching forward in silence, were lost in the hurly-burly of combat; the only means of communication available was by messenger. When the messenger became a trusted subordinate, as under Alexander the Great, the rudiments of a primitive staff began to emerge.

Like all military innovations, the phalanx was eventually replaced by another weapon system—the Roman legion. Although based similarly on the use of heavy infantry, the legion, unlike the phalanx, was organized flexibly in cellular units rather than in solid formation. This gave the legion greater maneuverability, but the corollary was less direct control. Nevertheless, extremely strong discipline and esprit, long and rugged training, and the expert use of trumpets, banners, and standards for signalling, made the legion a tight-knit fighting force, responsive to the commander's will.

In the early days of the Roman Republic, the military command system was deliberately designed to prevent excessive individual power. Except in times of crisis, when a dictator might be appointed, two consuls alternated in command of the army each twenty-four hours. In battle each consul had his own wing. Similarly, the tribunes, six senior officers of each legion, rotated in command, though later a legate was often appointed over them as legion commander, at which time the tribunes acted either as subordinate commanders or as staff officers.

As the power and territory of Rome expanded, it became impossible for one or two men to direct all military operations. A large and professionally competent officer corps developed, and from this corps a number of capable generals emerged to conduct innumerable campaigns of conquest, pacification, and retribution.

On the battlefield, under commanders like Scipio Africanus, Marius, and Caesar, a highly sophisticated doctrine of strategic and tactical maneuver arose. But the process of decisions still lay in the strategic and prebattle stages of operations. Nevertheless, the employment of messengers, trumpet signals, and personal example, combined with judicious employment of reserves, enabled these leaders to change the course of an unfavorable action.

The Roman legion remained supreme for roughly five centuries. Except for refinements and modifications, no major developments in military organization or command and control mechanisms occurred. In the latter part of the period, relaxation of discipline in the legions, civil unrest, and a general decline in Roman morale and national dedication accompanied an increasing use of missile weapons, which prompted dispersal and thinning out of infantry formations. The result of these developments was a significant decrease in the control of the legions by their commanders and a growing inefficiency in operations. The predominance of the legion ended at Adrianople in A.D. 378, when heavy Gothic cavalry defeated the Romans.

The Middle Ages

Before Adrianople, cavalry played only a supporting role to the more powerful, more reliable infantry. After Adrianople, heavy cavalry reigned supreme for nearly 1,000 years. During that millenium, cavalry tactics usually involved no standard military formations, but depended either on (1) the shock effect produced by a charge of mounted lancers or swordsmen, which sometimes disintegrated into a disorderly melee, or (2) the missile effect of mobile, lightly armored bowmen, whose very effectiveness depended upon a fluidity inherently inimical to close contact. Battlefield control, in either case, remained extremely difficult and relatively ineffective. Where discipline and structure were good, however, as in the divisions of heavy armored horse archers of the Eastern Roman Empire, or in the armies of Charlemagne, commanders exercised considerable control over their troops and over the direction of the battle.

The rise of feudal armies brought no improvement, for forces were generally untrained and lacked cohesive discipline, common organization, and unity of command. Since low-caliber infantry served as the base for maneuvering cavalry, the type of decision open to the battlefield commander remained primarily a question of where and when to launch the cavalry from the wings. Thus, structure, discipline, training, and the presence of the commander himself usually remained the arbiters of the battlefield. Virtually no decision except to take flight could be executed once the heavily armored feudal horsemen were committed.

The experience of the multinational forces which engaged in the Crusades, and the development at about the same time of the crossbow and longbow, raised the need for coordinated employment of infantry and cavalry and for discipline and training which would ensure coordination. Thus, by the end of the 12th Century, military anarchy gave way to somewhat disciplined and better organized formations which were more conducive to proper command and control.

On the other side of the known world, the Mongol military system of Genghis Khan made its appearance. In contrast, Mongol armies were extremely well organized, highly trained, strictly disciplined, and responsive to imaginative and effective command and control. Mongol leaders had absolute

authority over their men and, in turn, were held completely accountable to their superiors. Carefully planned campaigns were carried out according to previously determined schemes of maneuver and well-rehearsed tactics. While subordinate commanders were allowed leeway to execute a mission, they were tightly bound to conform to the over-all plan of campaign and battle. Extensive use of couriers provided communication between separated columns, and signal flags or flaming arrows ensured direction over tactical movements. Throughout the 13th Century, this extraordinarily sophisticated system enabled the Mongols to overrun most of Asia and to penetrate well into Central Europe.

The Mongol armies were the last of the great cavalry formations, for the defeat of feudal cavalry by English longbows at the Battle of Crecy (1346) signalled the return of infantry ascendancy--not infantry alone, but rather infantry supported by other arms. And during the centuries that followed, organization, discipline, training, and weapon systems overshadowed linkage and proved to be the keys to successful command and control.

The Early Modern Era

The introduction of gunpowder, and the development in the 15th Century of the first effective gunpowder weapons, opened an era of experimentation and change in military tactics and organization. The basic problem was to use firearms effectively in battle while protecting their users against the more numerous conventional weapons. This process of integrating firearms into offensive and defensive formations was slow; and trial and error pointed to the increasing importance of unified command and control.

The first formation to gain prominence in this era, however, did not rely on firearms. Nor was it really new. It was the Swiss column of heavy infantry, a reversion to the old Macedonian phalanx. A rigorously trained, strictly disciplined formation of pikemen, the Swiss formation employed mass; it relied on weight together with relative speed or mobility. Despite the introduction of handguns and arquebuses toward the end of the century, tight groups of pikemen remained the basis of Swiss success.

Inevitably, the Swiss phalanx gave way to formations making more imaginative use of new firearms. At the Battle of Bicocca (1522), Spanish arquebusiers, firing in controlled volleys, decimated the attacking Swiss and signalled the coming dominance of the Spanish "square". This new formation employed firearms and other weapons, as well as the basic pike, and used cavalry and newly developed artillery as supporting arms. But slow and intricate drill was required to load and fire the new gunpowder weapons, while arquebusiers, musketeers, and artillerymen were all extremely vulnerable to enemy action when they were reloading. To protect them, the operations of cavalry and other infantry were carefully coordinated. There soon developed the important and basic tactic of a controlled volley by a front rank of men, who would then retire to reload

while the rank behind them moved up to shoot. In like manner, cavalymen (especially the German reiters) were trained to ride close to the enemy, discharge their pistols, and retire to unload while another line of troopers charged sedately forward (at the trot) to displace them.

By the end of the 16th Century, although tactics had become fairly well universalized, the growing complexity of battle increased the difficulties of command and control. Technology, which had made great strides in weaponry, had yet to devise better forms of linkage than the standard methods of communicating by voice, signal, or messenger. In the heat, noise, and smoke of combat, victory fell to those trained and disciplined troops who were most responsive to their commanders.

Matters were further complicated during this period by the increasing use of mercenary troops, whose high standards of training and experience were offset by their disturbing tendency in crises to demand bonus or overdue pay as the price of dubious loyalty. Hence commanders were faced with a dilemma of alternatives: recourse to militia, undisciplined, poorly trained, and unreliable; or to expensive national standing armies.

Sweden's great 17th-century king and captain, Gustavus Adolphus, adopting the latter course, set a pattern and a model for military innovators during the next century. He employed a chief of staff, who acted sometimes as a tactical commander; a quartermaster, who was responsible for supply, movements, and quartering of troops; chaplains, judge advocates, provost marshals, surgeons; and chiefs of artillery, engineers, intelligence, and scouts. At the regimental level--another innovation--similar organization existed.

The result was a well-trained, disciplined army of combined and supporting arms to provide greater flexibility and power on the battlefield. Volley fire by platoon, rather than by a single row of musketeers, was also introduced; and this, together with improvements in small arms and field artillery, provided heavier and more carefully controlled firepower. Not the least of the Swedish king's innovations was to increase the mobility and maneuverability of his artillery; he employed this arm with skill and imagination.

Like all his triumphs, Gustavus' greatest victory, the Battle of Breitenfeld (1631), illustrated the importance of structure in successful military control. Later advances in weaponry, such as the bayonet which eliminated the need for pikemen, and improvements in fortification and siegecraft brought tactical change but no significant alteration in the mechanism of command and control. This was to be perfected by Frederick the Great, who by discipline and drill secured a considerable margin of mobility over his adversaries. Frederick's victory at Leuthen (1757), like his other triumphs, was a classic demonstration of the results to be achieved by perfectionism in structure and in tactical system.

Sea Warfare: From Ancient Times to Nelson

The procedures and mechanisms for directing and coordinating sea warfare developed far more slowly and subtly than those on land. Initially, armed men used trading or fishing craft to raid seacoasts, to repel raiders, or to transport themselves to sites for land battle. Control was a matter of individual command, involving little training or organization.

The first vessels specifically designed for fighting were produced by the Phoenicians about 700 B.C.: speedy, oar-propelled galleys which they, and later the Greeks, perfected. Naval tactics consisted of boarding or ramming, and sometimes both. Control depended on the training and discipline of individual crews and, to a limited extent, on fleet organization and primitive signalling methods. In order to hold the desired battle formation as long as possible, it was most important to maintain steady, synchronous stroking of oars to the beat of drums, the hammering of a staff against the deck, or other similar devices. Usually, once combat was joined, individual ships operated independently, although an able commander, such as Themistocles in the Battle of Salamis (480 B.C.) could coordinate the movements of skillfully handled vessels. Later, during the Punic Wars of the 2nd and 3rd Centuries B.C., Rome and Carthage developed extensive naval administrative organizations to control the operations of vast fleets raised by both sides. But on the whole naval operations continued for many years as disorganized engagements within sight of land between short-ranged, oar-propelled galleys.

Initially, the introduction of guns did not bring about any tactical changes which required naval command and control mechanisms of a higher order. But in the 16th Century, with the development of the sailing warship equipped with cannon of considerable power, the need for coordinated seamanship and controlled maneuvering increased. The concept of a ship of the line firing its batteries in heavy broadside to inflict maximum punishment began to emerge. The English victory over the Spanish Armada (1588), a triumph of planning, training, discipline, and, above all, long-range firepower, was the result of this powerful broadside combined with tactical maneuvering.

By the beginning of the 18th Century, the Royal Navy had evolved a set of Permanent Fighting Instructions—precise and detailed directives to guide warships in combat. Emanating from the Admiralty, these Instructions established rigid control over tactical maneuvering and restricted not only the movements of commanders but also the types and number of flag signals they could employ. Because the Instructions required absolute obedience to inflexible dogma, the fighting abilities and individual initiative of fleet commanders and ship captains were greatly hampered. Not until the Napoleonic Wars were bold and imaginative sailors like Nelson able to completely discredit the Fighting Instructions. And the resultant encouragement of initiative which granted relative independence to local commanders came, paradoxically, at the same time that an improved code provided far more effective means for preserving tactical control.

The French Revolution and Napoleon

The "nation-in-arms" concept exemplified by the mass armies of the French Revolution and Napoleon multiplied the problems of command and control. To turn the columns of the French Republic from ineffective mobs into the scourge of European battlefields for almost two decades, Napoleon (building on a structure started by Carnot) employed four concepts of control: (1) to obtain speed of movement and concentration, applicable both strategically and tactically, he established self-contained divisions and corps, commanded by experienced subordinates, which he directed not only by masterful advance planning but also by means of the semaphore and telegraph; (2) to harass and deceive the enemy, to keep him off balance and confused while preparing to strike a typically massive and decisive blow at a critical spot, Napoleon used skirmishers to precede his columns and engage the enemy (Though this was not a new concept, Napoleon utilized it more effectively than any of his modern history predecessors.); (3) to smash a gap in opposing formations through which the infantry might plunge, he grouped his artillery in mass, under his own personal control; and (4) to deliver the final stroke, or to counter-attack decisively, he employed a reserve as the culminating blow of a series of concentrated punches.

As with Genghis Khan, Napoleon could not have executed his far-ranging campaigns without affording wide latitude for action to some of his more capable subordinates. Sometimes, as at Auerstadt when Davout defeated a far superior force, he was amply repaid. In general, however, personal jealousy and political expediency kept him from permitting his marshals to become first-rate commanders in their own right; for this he paid dearly in the long run. The ineptitude of his subordinates in Spain, Russia, and Germany led to his empire's decline; and his lieutenants' errors set the stage for his final disaster at Waterloo.

Napoleon operated during the dawn of the Industrial Revolution when mass armies were a reality; but expanding technology gave only a glimpse of the deadly weapons of the future. It was still too early for communications developments to permit improved battlefield control of the new masses and the increasing lethal power available to them. Though Napoleon's genius overcame some of these problems, the period remained, in a sense, an anomaly, for the campaigns of 1812 and 1813 (Moscow and Leipzig) illustrated how the emperor's strategic ambition overran existing and previously successful French command and control procedures.

The Post-Waterloo 19th Century

The great strides in military technology resulting from the Industrial Revolution tended both to complicate and mitigate the problems of command and control. Industrialization, which freed more manpower for the armed forces in time of war, presented commanders with the difficult task of

directing huge masses of poorly disciplined troops. Longer range, greater accuracy, and the higher rate of fire of new weapons encouraged dispersal, broad and rapid maneuver, and a general disinclination to close with a well-entrenched enemy.

Mass, man-killing firepower, and improved communications were the three 19th-century developments that were to transform the art of war. These first appeared in the Crimean War, but had little impact until the American Civil War. Their combined effect produced a tremendous dispersion of military forces, both tactically and strategically, and a consequent decentralization of command. Except in a broad, strategic sense, management of battle passed from the hands of a single supreme commander into those of his subordinates; the supreme commander directed rather than commanded.

Since large forces, widely spread and closely organized, could not be commanded with precision, dispersal and poor control served only to encourage a tendency to straggle. And, as the battles of the American Civil War proved, once relatively undisciplined troops began to fall back in disorder, it was almost impossible to regroup them on the battlefield. Additional aggravation ensued when politically chosen Civil War officers and short-term enlistees proved less susceptible to military control than regular officers and troops with long-term enlistments.

But if technology led to tactical developments that prevented tight command and control, at the same time it did much to reverse this trend. The wide utilization of the telegraph and cable during the Civil War linked commanders with distant units more rapidly and efficiently than ever before. The commander in chief in Washington, if he so desired, could communicate with a division commander in the field so speedily as that division commander could send a messenger to a company on the line. And the telegraph put into the hands of government an adequate means of restricting military commanders who were far from the capitol. In contrast to the experience of Washington in the American Revolution, and Wellington on the Peninsula, the central control possessed by Lincoln clearly delineated military subservience to political, civilian control in a way scarcely known before.*

At shorter range, communications were facilitated by improvements in the semaphore and heliograph, while balloon observations assisted commanders in locating their own as well as enemy troops. Steamboats

*This was also in part the result of increasing democratization of government; see Appendix D.

and locomotives facilitated both decentralization and concentration, while providing commanders greater mobility, more flexibility, better communications, and faster, more reliable means of reinforcement and supply. Whether strategic control was enhanced or diminished as a consequence of these conflicting developments is moot. The fact remained that for the tactical commander on the battlefield means of command and control were still much the same as in Alexander's day at Arbela--discipline, training, voice, signal and messenger, and personal example. The high incidence of battlefield deaths among commanders operating at corps and lower levels illustrates this point, as do the numerous examples of failure of decisive maneuver for want of proper timing.

During the latter part of the 19th Century, European armies experimented with improvements in the military staff system both for prebattle planning and battlefield control. Under Scharnhorst and Moltke, Prussia developed the concept of a General Staff to coordinate and direct the entire national military effort. Combining careful research, meticulous planning, and complete devotion to a logical efficiency, the staff became a dedicated group of officers who provided the commander in chief with the only means by which he could possibly control the huge Prussian army with its varieties of units and equipment. In time of war, the close connection between the Great General Staff and the general staffs of operational units resulted in unprecedented unity and coordination. The control of the General Staff ensured Prussia's successes in wars against Austria (1866) and France (1870-1871) and set a standard for other nations to follow. By the early years of the 20th Century, all major military powers had adopted general staff systems.

World War I

World War I introduced new arms, new tactics, and, indeed, entirely new concepts of warfare. On land, weapons like the machine gun, the automatic rifle, and quick-firing artillery put an end to maneuver in the open and to gallant charges of cavalry or heavy infantry. Instead, the shovel became the soldier's most important weapon. An attack was an attempt by the artillery to blast a hole in the entrenched enemy's line big enough for the infantry to exploit. Thus, proper control of the infantry-artillery team became the most important factor, both offensively and defensively.

In the attack, it was necessary to coordinate preassault bombardments, rolling barrages, and counterbattery fire with the forward movement of the infantry. Defensive fire required equal control, especially when shifting to cover infantry counterattacks. Artillery, therefore, was precisely deployed, and its fire carefully controlled by forward observers, airborne balloon observers, and complicated mathematical calculations.

Emphasis was also given to the proper organization of infantry formations. Experience indicated that, in a formation to be controlled by a single headquarters, efficient span of control dictated that no less than three-and no more than six-- units should be grouped together and that, on the lowest tactical echelon, the largest unit which could be effectively commanded by one man was the platoon of fifty or fewer soldiers. For further control, operations were carefully planned in advance and subordinate commanders were enjoined to follow detailed pre-arrangements, as the tremendous artillery barrages completely disrupted communications. Telephone wires were cut; transmission over relatively primitive radio sets was drowned out; and commanders were forced to fall back on flags, whistles, flares, and signal lamps. The carrier pigeon made a heroic, but unreliable, appearance; and multicolored flares probably proved to be the most reliable means of tactical communication.

A general collapse of high-level control occurred in the opening clashes on land in 1914. This was as true of the ill-fated Russian offensive into East Prussia as it was of the German wheel through Belgium into France. The obvious lesson was that, in operations undertaken on such a grand scale, army and corps commanders required the closest possible supervision over their movements in order to assure coordinated response to unexpected developments. Although inadequate communications were obviously the principal weakness, structure, in spite of stresses and strains caused by the staggering casualties of the opening engagements, held up surprisingly well.

The second phase of World War I (1915-1917) became a stalemate on land. This period was characterized by breakdowns in intermediate commanders' control over fighting units, often down to the company level. Under the pressure of massed artillery and machine-gun fire, formations lost all coherence (frequently before even reaching their jump-off positions). Units often lost touch with adjacent units on their flanks and even with their rear echelons. Information reports on the location of friendly and enemy troops also failed and commanders could not commit reserve forces in a decisive way. More often than not, enemy fire and devastated terrain blocked the approach of reserves and coherence was lost before the point of contact was reached. Under these conditions few decisions were open to commanders; they could repeat maneuvers with other units, call for more and more artillery fire, dig in--or fall back.

Two aspects of this period deserve particular emphasis. The first was the difficulty, indeed failure, experienced by commanders in holding down the scope of commitment commensurate with intended objectives. Nowhere was this more tragically demonstrated than Falkenhayn's experience at Verdun. Here, in all its portent and tragedy, is a clear example of the term "escalation". The simple need for more troops, always more troops, caused Falkenhayn's subordinates, and ultimately the German High Command itself, to reverse their intentions completely. Turning down ardent requests that arise in circumstances like these requires a commander to be utterly assured of his purposes, of his intellectual grasp of the course of battle, and of the control of his forces. In somewhat different context, the British experience at Passchendaele underscores this same point.

The second aspect of the stalemate period was the development, on both sides, of elaborate and successful systems of artillery fire control. By means of them, the infantry in attack was first supported by rolling barrages behind which it might advance and then with timely fire against counterattacks once the objective had been gained. Detailed coordination between infantry and artillery, frequently with pyrotechnic signals, permitted rapid calls for fire. Teamwork between the two arms was the key to penetration of enemy defenses, but the inability to extend this coordination into an exploitation phase remained a major factor in the lack of decisive success.

In land fighting in 1918, during the third phase of World War I, infantry-artillery coordination was a basic feature in a German innovation: the "Hutier Tactics". Producing spectacular results first in Russia, then on the Italian front, and later in Ludendorff's great offensives on the Western front, the new tactics employed small German combat groups which sought weak spots in the line, bypassing strongpoints (to be eliminated later by reserves), and pressed irresistibly forward like water pouring across a bed of boulders. Troops were ordered to go as fast and as far as they could. However, the problem of sustaining this type of attack was not solved. Torn-up roads and shell-churned fields impeded essential artillery and logistical support; neither trucks nor horses could keep pace.

Nevertheless, despite these strategic German failures, commanders on both sides brought the tactical aspects of trench warfare largely under their control by combining traditional operational methods in the "Hutier tactics" pattern with the newer linkage provided by artillery control systems and the airplane. The major control procedures included: (1) attack objectives strictly limited by phase lines, on which, once gained, the troops dug in and consolidated immediately for defense; (2) combination of aerial reconnaissance and forward observers with assault troops; (3) tight but flexible control of artillery support against counterattack; and (4) systematic widening of the attack frontage to absorb the pressure of counterattack. These progressive steps, repeated in sequence, restored tactical control to junior officers and noncommissioned officers in assault units, relieving superior officers of detailed combat control. The superior could then devote himself to the all-important command decision of the commitment of reserves.

Concurrently, changes in combat at sea took place. A great diversity of ship types appeared--notably submarines and the great battleships known as "dreadnoughts". In the early years of the war, naval combat doctrine remained relatively inflexible, discouraging independent squadron action outside main formation. But improved electronic direction systems enabled commanders to concentrate battery fires on a single target. And better radio communications allowed control of distant warships.

Among the more carefully controlled sea operations was the convoy system, adopted to combat the extremely effective German submarine campaign. Closely guarded groups of merchant ships, their movements precisely planned and coordinated, followed prearranged courses; but when necessary, because of the longer range of more powerful radios, rapid shifts and regroupings could be put into effect. By introducing new procedures and mechanisms of command and control, both in structure and linkage, from the tactical to the political level, World War I set the pattern for later developments and, indeed, for much of World War II.

World War II

By the end of World War I, commanders on both sides had regained a measure of control over the battlefield; but shortcomings in linkage mechanisms—both signals and transportation—still imposed severe restrictions on the employment of mass armies and increased firepower. The method of restoring mobility to the battlefield was introduced with dramatic suddenness at the start of World War II, when the Germans employed vastly improved transport and electronic communications facilities (particularly at the tactical level) and organizational innovations. To a greater degree than ever before, the combined arms concept was applied. The tank, truck, self-propelled artillery, and fighter-bomber aircraft provided a means for swift exploitation, and vastly improved radios and telephones provided similar means for controlling fast-moving, far-ranging formations. For the first time, all three elements that revolutionized modern war—mass, man-killing firepower, and communications—were present in equal degree. Technology, which had presented the commander with ever-escalating responsibilities in terms of mass and firepower, had at last provided mechanisms sufficient to deal with and surmount them.

Tactically, World War II was primarily a war of maneuver. The pattern set was blitzkrieg (lightning war)—the result of study by the Germans of their exploitation failures in 1918. Classical doctrine in principle, the blitzkrieg concept, based on careful planning executed by subordinates, permitted wide latitude of initiative in attaining the desired objective.

Control of land operations on both sides was accomplished through elaborate pyramidal organizational structures, considerable training and discipline, sophisticated communications equipment, and complex staff, administrative, and command relationships. These factors permitted impressive coordination of infantry-artillery-tank attacks, closely supported by aircraft, as well as close cooperation between different types of aircraft, and amphibious and airborne maneuvers.

These were the most tightly knit control systems in history (exemplified by Allied and interservice unified command at high echelons and regimental or battalion combat teams on the tactical level); but despite this fact, there was great flexibility and initiative in subordinate commands. Small groups, which infiltrated far behind enemy lines, or

which were separated from parent units by distance or difficult terrain; parachute and glider units, which fought almost independently; armored task forces, which sliced into the enemy rear to engage targets of opportunity—all operated within a framework of general plans or directives, adhering to training, doctrine, and discipline as well as advanced communications systems.

The speed of the new warfare introduced new situations for decision-making, particularly those which bore on countermeasures. Delay could spell irretrievable disaster, as in the dilatory actions of French commanders after the Germans jumped the Meuse in 1940. In addition, momentous consequences hung on decisions in battles spread over entire nations. And furthermore, with war of such scope, moving so rapidly, decisions were often irrevocable.

Improved communications, placed in the hands of the heads of state, provided rapid means of personal intervention in military decisions. No longer could a commander cut his communications and operate independently, as Sherman and Grant had done in the Civil War. Yet Allied leaders made relatively few intrusions on the prerogatives of the field. Though Roosevelt and—particularly—Churchill sometimes overrode their military advisers and kept close touch with field operations, for the most part the two major Allied chiefs operated within the framework created especially for conducting the global war—the Combined Chiefs of Staff.* Hitler, well advised by his military staff, did much the same in the early months of the war, although he was quick to take matters into his own hands in Russia, where he created a centralized command system which eventually stultified maneuver and initiative in all theaters. Mussolini left military control altogether to his chiefs. And Stalin's direct political control in Russia was apparent, though the system of political commissars attached to tactical headquarters became of relatively small importance later in the war. In Japan, the military retained control of the government until the closing days of the struggle.

The complex problem of allied control in World War I still existed in World War II. Yet when the United States entered the war, accord with the British on unified command was intrinsic from the start and, in general, decisions at the allied level were remarkably free of rancor. Agreement between the Western Allies and Russia, however, was hard earned, except on the broadest of issues; but separation of the two battlefields ameliorated this condition.

Throughout the war, there were dramatic failures in communications, mainly attributable to the human element. Indeed, this was most tragically evinced in the first hours of the war at Pearl Harbor. But later, there were communications failures at the tactical level, too. In the

*See also Appendix D

invasion of Sicily in 1943, Allied land and naval forces opened a deadly fire in the darkness on planes carrying Allied paratroopers to the attack. And in Normandy, in July 1944, a scheduled Allied bombardment by an air armada, which included strategic bombers in direct support of a ground offensive, was cancelled too late to halt the first waves of bombers, who then mistook the bomb line and inflicted severe casualties on American troops. In Holland, later in 1944, the light radio sets carried by British airborne troops dropped beyond the Neder Rijn River lacked range. In consequence, the high command was unaware of failure of the troops to attain their objective until too late.

Additionally, there were intentional communications failures brought about by commanders who wished to conceal their plans or their reverses from superiors. General Mark Clark, during the drive on Rome in May 1944, after consciously violating instructions from his superior, British Field Marshal Alexander, absented himself from his command post until it was too late for Alexander to intervene. On more than one occasion, Generals Patton and Bradley circumvented SHAEF directives in France. German commanders, under strict orders from Hitler not to give up ground voluntarily, reported withdrawals as forced. In February 1945, the commander of the German Seventh Army ordered his subordinates to submit two daily operational reports: one for transmission up the chain of command to Hitler; and another—true—report for army use. At lower levels on both sides, commanders sometimes colored reports to spare themselves and proper decision-making was often impeded.

There were intelligence failures, also. And, again, Pearl Harbor was one of the most dramatic examples. Others were: the French failure to divine the main effort of the Germans through the Ardennes in 1940; and the American failure to detect the German concentration in the same Ardennes in 1944. Even after the D-Day invasion of France had begun in 1944, German intelligence failed for a long time to realize that it was the main Allied landing. And in another instance, the first German blow against the Soviet Union in 1941 gained tactical, if not full strategic, surprise.

These failures, however, were far from being the rule. In stable situations, telephones (as low as squad level) enabled commanders to bring rapid fire support to bear and, in offensive operations, radio networks down to intracompany systems permitted commanders at higher levels to get quick information on which to base their decisions. Radios also made possible tight control of tanks and aircraft, even in far-ranging operations, and enabled fighter aircraft to act sometimes as artillery support. Radio also facilitated ship-to-landing craft and ship-to-shore contact in amphibious operations. Although there were occasional instances of misdirected artillery fire because of human error, in general, radio, telephone, and electronic computer in the fire direction center provided trustworthy means of artillery fire control. Old methods of control also

could be adjusted to the new situations. Commanders might exercise control by the strength of the forces they provided for a mission, by committing additional forces or reserves, by specifically designating objectives or phase lines, by using liaison officers, and by personal contact.

Perhaps one of the most dramatic illustrations of the effectiveness of the new procedures was the control exercised over the Royal Air Force Fighter Command early in the war in the Battle of Britain (1940) when a numerically inferior British fighter force, aided by strict control and direction provided through radar, radio, and telephone-equipped ground observers and tied in closely with ground antiaircraft defenses, defeated German attempts to clear the British skies as a prelude to invasion. While the fighter pilot might retain considerable latitude once engaged in aerial duel, he rose to the fight only at the signal of a centralized command in a procedure that minimized the possibility that defensive strength might be drawn off the main target by feint.

The fact was, improved communications at last effectively linked the fighting front--air, sea, or land--from bottom to top and in the process provided commanders with the information they had to have in order to make the proper decisions. Capture of the Remagen bridge across the Rhine, for instance, flew progressively up command channels with such remarkable speed that Eisenhower's decision--involving a complete change of plan--was made approximately seven hours after the first U.S. troops rushed across the structure.

The linkage mechanism of transportation also served both sides well. The only real problems lay in shortages and in the mechanical limitations of the vehicles, ships, or planes. The Russians never were as well off for transport as other nationalities, but with U.S. aid and their own ingenious use of horses, they made do apparently without serious limitations on operations. In the last year of the war, the Germans were drastically short of planes of all types, of aviation gasoline, and of trucks and self-propelled artillery. On the Allied side, not until late 1944 were sufficient landing craft available to remove restrictions on amphibious operations, and not until 1945 were transport aircraft on hand in sufficient numbers to deliver an entire airborne corps in one lift. These shortages influenced, of course, the decisions as to employing amphibious and airborne troops and in some instances were decisive. Enough transport aircraft to deliver simultaneously all three airborne divisions engaged in the Allied attack in the Netherlands in September 1944 might have meant unequivocal success in that operation. But in general these shortages acted more as a restraining influence on the range of strategy or tactics rather than on success or failure.

Similarly, though trucks, tanks, and self-propelled artillery made possible exploitation thrusts to a depth of several hundred miles, throwing enemy communications into disarray in the process, mechanical limitations and the sheer size of the task of supplying large forces at such distances eventually brought the drives to an end short of total victory. At such point, another phase of relatively stable warfare ensued until a new breakthrough could be achieved and another exploitation staged. In all theaters, particularly in the Pacific, the range of land-based fighter aircraft or the availability of carrier-based planes, limiting the scope of amphibious operations, influenced decisions.

Yet just as with signals communications, transport basically was capable of doing the job demanded of it. When coupled with improved structure—organization specifically designed for the job assigned, like the regimental combat team, the armored combat command, the battalion landing team—the new methods of communication and refined adaptations of the old had at last caught up with mass and man-killing firepower on the battlefield.

Conclusions

Because of the burgeoning technology, the complexities of command and control have reached staggering proportions since World War II. At the tactical level, proper organization, discipline, training, and communications have permitted a continuation of World War II's happy combination of control and initiative, as particularly exemplified in Korea by UN forces. But the possibility of unleashing increasingly "gross" acts by increasingly lethal weapons has imposed increasing responsibility at all echelons of command. Whether augmented training to cope with these complexities will render personnel on lower levels so sensitive to the results of their acts that they will question, or even refuse to accept, a "go" order is a subject that warrants further study. As yet, there does not appear to be a clear consensus of how to relate responsibility and initiative to a theoretically "permissive" control system.

At higher levels, problems of command and control are raised by huge armies and air forces equipped with incredible firepower, vast fleets with self-contained air forces, and unprecedented new arms and delivery systems in the process of development. So far, the twin concepts of structure and linkage have been adequate to hold centrifugal military forces in check. Yet the future imposes the necessity of finding clearcut restraints on man's ability to destroy himself while, at the same time, insuring a command and control system that has validity and produces compliance.

APPENDIX D

A SURVEY OF THE HISTORY OF POLITICAL INVOLVEMENT IN MILITARY COMMAND

I. Introduction

Control of its military power is a prerogative of organized government, stemming from the fact that the military constitute an arm of government and are, therefore, subordinate to the authority of the head of state. This principle of political control, loosely termed "civilian control" in this country, has existed throughout the course of modern history.

It is pertinent to note that Jomini and Clausewitz, the two prominent students of war whose writings have most affected professional military thought since the early part of the 19th Century, attest to the validity of the principle but are careful not to attempt empirical delimitation between political and military control. Jomini stresses that primary consideration must be given to "la politique de la guerre" or political factors in war. "We give this title," he writes, "to the combinations by which a statesman [italics supplied] must judge whether war is proper, opportune, or even indispensable; and what must be the diverse operations essential to accomplish his objective."¹

He further points out that the unexpected psychological and political factors which will be encountered in prosecuting a war cannot be resolved by tables of probability. Hence, plans of operation must be modified in accord with circumstances, although for their execution one must remain faithful to the principles of the art."² And again, Jomini warns that the statesman [italics supplied] must seize upon such modifications as circumstances and localities dictate."³

Clausewitz says:

The subordination of the political point of view to the military would be unreasonable, for policy created the war; policy is the intelligent faculty, war only the instrument, and not the reverse. The subordination of the military point of view to the political is, therefore, the only thing which is possible.

Deep-rooted American solicitude that "civilian control" be held inviolate stems as a corollary to the axiom enunciated by Clausewitz. Fear of tyrannical military dictatorship dates back to the time when war was considered "the sport of kings", and the whim of warrior-kings dictated the fate of the population. This dread was aptly expressed by Governor John Winthrop of the Massachusetts Bay Colony in 1638. At that time, when the Ancient and Honorable Artillery Company of Boston applied for

the first volunteer militia charter in the Thirteen Colonies, he said:

...The Council considering from the example of the Praetorian Band among the Romans and Templers [sic] in Europe how dangerous it might be to erect a standing authority of military men which might easily in time overthrow the civil power, thought it fit to stop it betimes...^

Individual civilians and/or civil bodies have intervened in military operations throughout history. Hence the gamut of historical experience is wide; it runs from delineation of policy to complete command and control of military field operations.

II. Europe

In 17th-century Europe, control of military operations by influential nonmilitary individuals was notable in both France and England. For instance, Cardinal Richelieu, who was Louis XIII's chief minister, exercised a very direct personal control over France's domestic and foreign military operations.⁸ And in England, the Cromwellian "Instrument of Government" (1653) was forerunner of the "Declaration of Rights" (1689), which radically changed the administration of the English government. (By the terms of this instrument, while the head of state remained as titular commander in chief of the national forces, ultimate control passed to Parliament. Henceforth, standing armies could not be maintained in peacetime without Parliamentary sanction, which was implemented by control of the national purse-strings.) As a result, William of Orange, when he became King William III by Parliamentary edict (1689) found his powers as traditional commander in chief drastically curtailed by cabinet ministers.⁹

Concurrently (1643-1715), Louis XIV was assisted in his brilliant military era by three of his civilian ministers: Louvois, minister of war, who reorganized old armies, developed campaigns and improved the welfare of the troops in the field; Colbert, minister of finance, who schemed to reorganize the navy, advised on and planned colonial and maritime expansion; and Vauban, the great engineer, who wore three hats--as civilian administrator-advisor, military commander, and master engineer.¹⁰

During much of the Seven Years' War, England's armed forces operated under tight political control. William Pitt (the Elder) was appointed Secretary of State in 1757 and used his powers lavishly in the conduct of the war. Dictatorially, he directed operations overseas through linkage, which was remarkable for that era.⁹

The French Revolution (1789-1799) was, of course, in the beginning, chiefly a civilian-led rebellion against the decaying remnants of the French monarchy. The man who became known as "the organizer of victory"

« of this people's revolt was Lazare Nicolas Carnot, distinguished engineer, mathematician, physicist, and former soldier. Carnot's operational control of French armies was direct and ruthless and, by 1792, he had affected changes in French military organization and doctrine which led directly to a series of remarkable French victories.

Eventually, Carnot became responsible for "deputies on mission" or the civil control of promotion and demotion of officers at the front. An able military man in his own right, he himself constantly joined—and inspired—the armies in the field and, throughout his career, instigated new tactical and logistical procedures.¹⁰

In the 19th Century, the Franco-Prussian War (1870-1871) presents an outstanding example of political control of the military. At that time, both Napoleon III and his adversary, Prussian Chancellor Bismarck, involved themselves with the operations of their respective armies. Late in 1870, Napoleon appeared in the field to command his French armies, adding difficulties to France's already disastrous position; his defeat at the Battle of Sedan caused the fall of his empire. Bismarck, from the beginning of the war, irritated the German General Staff with his tendency to concern himself ("meddle" was the professional label) in military affairs.¹¹ After the victory of Sedan, the Chancellor became even more involved, conceiving a plan for receiving direct communications from field commanders; later, he also concerned himself with operational details for the siege and capture of Paris.

• During World War I, political control on the Allied side was hazardous at first, but later became clear-cut and formalized.¹² Lloyd George, British Prime Minister, exercised such control that, in the spring of 1918, he actually refused reinforcements to Haig, his field commander; and
* Clemenceau, French Premier, often stated that war was far too serious a matter "to be left to the generals".

In the Allied Supreme War Council, Lloyd George, Clemenceau, and Italy's Orlando exerted continual influence upon military commanders and even attempted to pressure President Wilson to remove General Pershing from command of the AEF.

At the outbreak of World War I, Winston Churchill, first Lord of the Admiralty, had played **gn** active and effective role in mobilizing the British navy. Later, Churchill personally participated in the defense of Antwerp after the Germans had invaded Belgium. Churchill's role in the decision to undertake the Dardenelles campaign (1915), and in the planning for that operation, exceeded that of cabinet minister (as, in fact, did Kitchener's as Secretary of State for War).

^ In World War II, Churchill's role in command and control began with his direct supervision—as First Lord of the Admiralty (September 1939-May 1940)—over Royal Navy operations during the Norwegian campaign.

Later, as Prime Minister and Minister for Defense, he carried his dynamic influence through the strategic level into tactical planning for the employment of both troops and weapons. His directives, admonitions, and orders to individual commanders in the field ripped through the maze of traditional chains of command. "Phantom", his own personal forward reconnaissance network, composed of liaison officers equipped with adequate and rapid means of communications, kept him advised of daily operations on all fronts, frequently well in advance of military situation reports.

On the Axis side, Adolph Hitler's personal control of field operations was absolute, though it should be noted that this political control was exercised ad absurdum and contributed greatly to the fall of the Third Reich.

In the Soviet Union, Joseph Stalin's control of field forces was tight; it is clear that political overlordship intervened frequently in tactical situations (as, for instance, the halt outside Warsaw in 1944), but the extent of this involvement is not fully known outside of Russia.

III. The United States

With the coming of the American Revolution in 1775, the Continental Congress resolved to exercise supervisory control over all military operations through a Congressional committee. Commander in Chief Washington kept in close touch with this civilian group, which was often understandably discouraged with the lack of progress and of victory in the lengthy war. Nevertheless, in only one major instance did the committee intervene directly in field matters. In 1780, Congress appointed General Horatio Gates as Washington's co-equal, in command of the newly established Southern Department, created to deal with the British shift in concentration to the South. Gates was ignominiously defeated at Camden (August 16, 1780), and Washington's responsibility as pver-all Commander in Chief was soon restored by a penitent Congress.¹⁴

Within a few years following the Revolution, the framers of the Constitution wrote into that document their convictions for political control over the military—convictions based on experience in the American Revolution combined with their heritage from England. With a few minor modifications, the framers reproduced in the Constitution the division of authority over the military which prevailed in England and the colonies in the middle of the 18th Century.¹⁵ In effect, the President inherited the powers of the English King, and Congress, the powers of the English Parliament. The major difference lay in war-declaring power for, by vesting Congress alone with that power, the framers altered British practice and established a significant precedent in the evolution of constitutional government.

The obvious intention of the framers was to grant the President almost unlimited authority as commander in chief of the national armed forces, including—if he so desired—assumption of personal command in the field. The one, clear-cut limitation on this authority was the constitutional prerogative of Congress "to raise and support armies [and] to provide and maintain a navy".⁶

Not until the last decade of the 19th Century was there further attempt to define the President's authority. Then, two Supreme Court decisions reaffirmed his unlimited control: "The object...is to vest in the President the supreme command over all the military forces, such supreme and undivided command as would be necessary to the prosecution of a successful war". And,

Congress has the power not only to raise and support and govern armies but to declare war. It has, therefore, the power to provide by law for carrying out war. This power necessarily extends to all legislation essential to the prosecution of war with vigor and success, except such as interferes with the command of the forces and the conduct of campaigns. That power and duty belong to the President as commander in chief [italics supplied]____ But neither can the President, in war more than in peace, intrude upon the proper authority of Congress, nor Congress upon the proper authority of the President.¹⁸

Meanwhile, political intervention in military command and control had been exercised on numerous occasions. President Madison and his cabinet, on August 24, 1814, actually took a brief part in battlefield command at Bladensburg. Before he fled that field, however, Madison told his War Secretary, John Armstrong, who was issuing orders to the American commander, Brigadier General William H. Winder, that "the military functionaries should be left to the discharge of their own duties, on their own responsibility".¹⁹ Several years later, during the Mexican War, the presidential prerogative was invoked by President James Polk in two instances: first, by his repudiation of General Taylor's armistice agreement with the Mexican commander, General Ampudia, at Monterey in 1846; and second, by his arbitrary (but legal) removal of General Scott from command in Mexico in 1848.²⁰

In the Civil War, there were numerous examples of political intervention, both presidential (legal) and congressional (strictly speaking, illegal). In the latter case, following the Union defeat at Ball's Bluff, Virginia, in 1861, Congress established a Joint Committee on the Conduct of the War, "to keep an anxious, watchful eye over all the executive agents who are carrying on the war at the direction of the people". This group, predominantly Radical Republicans, believed, in the words of a member, that: "We are not under the command of the military of this country. They are under ours as a Congress." Throughout the remainder of the war, this committee plagued both the President and the military command, often dictating military policy by sheer political power.²¹

Both Presidents—Abraham Lincoln and Jefferson Davis—took active part in the formulation of military policy and even in actual direction of military operations. Although Lincoln realized his military limitations, he assumed personal command of the Federal armies for a while, exercising this command through his Secretary of War, Edwin M. Stanton, from March 1862 until July 1862. During that time, the office of the General in Chief remained vacant; but after the disastrous Second Bull Run Campaign, General Halleck was named to fill that position. Lincoln's Civil War experience demonstrated that, in his desire to obtain a formula for victory, he and other inexperienced civilian authorities resorted to experimenting with military affairs.²² Not until 1864, when Lincoln "found" Grant, did he have a general to whom he was willing to entrust full military responsibility.

On the Confederate side, President Jefferson Davis, an experienced West Pointer, frequently intervened in field operations and "became too involved in the details of the Confederate War Department ... in minor matters of army administration, to the annoyance of his five successive Secretaries of War, and to the despair of many of his generals".²³ As opposed to Lincoln's relationship with Grant, Lee seemed to feel obliged to continue to check out his every action with the President, after Davis belatedly made him General in Chief.

Militarily, the Spanish-American War of 1898 was a relatively minor event; but associated with it, is one unique example of civilian intervention in military affairs. Assistant Secretary of the Navy Theodore Roosevelt, soon after the USS Maine was sunk in Havana Harbor (February 1898), without consulting professional naval officers or his civilian chief, sent a message to Commodore George Dewey, ordering his squadron to Hong Kong. "Keep full of coal," Roosevelt ordered. "In the event of ... war your duty will be to see that the Spanish squadron does not leave the Asiatic coast, and then offensive operations in the Philippine Islands

During World War I, there were only two conspicuous instances—both limited to initial strategic decisions—when there was political intervention in military operations. These were: participation in the ill-fated Allied North Russian adventure of 1918 and the American Siberian expedition in 1918-1920. Once in the war, President Wilson was meticulous to avoid interference with his professional military command. He gave his field commander, General Pershing, free hand and unqualified support, while his War Secretary, Newton D. Baker, faithfully carried out the President's wishes. Overseas, Wilson's representative on the Supreme War Council, Major General Tasker H. Bliss, loyally protected both his chief and Pershing from the sometimes insidious, frequently dictatorial efforts of Allied chiefs of state to intervene in American command and control.³

In World War II, insofar as the United States was concerned, political intervention in strategic command and control was ubiquitous in the delineation of policy and grand strategy, since the Big Three-Roosevelt Churchill, and Stalin-dictated it, and the Allied Combined Chiefs of Staff and the U.S. Joint Chiefs of Staff directed it in the various theaters of war. President Roosevelt was almost as meticulous as Wilson in leaving purely operational matters in the hands of military subordinates whom he trusted. 'In one instance, however, because of political pressure, the President insisted that General Chennault be given greater operational latitude in China than was deemed advisable by Generals Stillwell, Marshall, and Arnold.

IV. Conclusions

The Korean War, with its limited and precise objectives, reaffirmed the concept that political command and control must override divergent views of the military in the field. The summary relief of General Douglas MacArthur by President Truman emphasized this fact.

The modern, nuclear-age trend toward increased political involvement in command and control has been repeatedly demonstrated in various cold war noncombat crises. In the Cuban-Soviet missile affair, for instance it is alleged that White House directives cut through the normal Navy ' chain of command with instructions to individual warships.

nTM ^ T^{ry} . fa f that the " = P^o yTM " fe y U.S. troops of nuclear weapons now depends--by law--on presidential assent is evidence that the nuclear age has pushed the command and control responsibility of the President directly to the front ranks of combat. It would appear essential, then that an exhaustive study be made to evaluate the potentialities of this situation, both as regards the national defense and the effect of such imperative, personal control on both initiative and discipline in successive levels of military command and control.²⁶

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6. William L. Langer, Encyclopedia of World History (Boston: Houghton Mifflin, 1952), p. 387. See also J. F. C. Fuller, A Military History of the Western World (New York: Funk & Wagnalls, 1955), II, pp. 46-73, passim.
7. Langer, op. cit., p. 431
8. Langer, op. cit., p. 442.
9. John C. Long, Mr. Pitt and America's Birthright (New York: Stokes, 1940), pp. 245-331, passim.
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15. U.S., Constitution, Art. 1, sec. 8 and Art. 2, sec. 2.
16. Ibid.
17. U.S. vs Sweeney, 157 U.S. 281 (1895)

18. Ex parte Mllligan. 4 Wall. 2, 139 (1866); Swaim y U.S. 28 Ct. CI. 173, 221 (1893) affirmed 165 U.S. 553 (1897).
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20. Charles W. Elliott, Winfield Scott (New York: MacMillan, 1937), pp. 553-575, passim.
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22. Dupuy and Dupuy, op. cit., passim.
23. Ibid., p. 284.
24. As quoted by E. B. Potter and Chester W. Nimitz (eds.) in Sea Power (New Jersey: Prentice-Hall, 1960).
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17

DEVELOPING A METHODOLOGY TO DESCRIBE
THE RELATIONSHIP OF MOBILITY
TO COMBAT EFFECTIVENESS

17 February 1967

HISTORICAL EVALUATION AND RESEARCH ORGANIZATION

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DEVELOPING A METHODOLOGY TO DESCRIBE
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TO COMBAT EFFECTIVENESS

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INTRODUCTION

Purpose of the Study

This study, "Developing a Methodology to Describe the Relationship of Mobility to Combat Effectiveness," has been undertaken for the Research Analysis Corporation (RAC) by the Historical Evaluation and Research Organization (HERO). In essence, the study directive (reproduced in Appendix A) requires HERO to examine the extent to which mobility has historically been related to the combat effectiveness of land forces, and in the process to ascertain the possibility of deriving from historical experience a methodology for describing this relationship in terms currently useful to the US Army.

Study Concept

In light of the fact that less than seven weeks were available in which to perform this study, and in consideration of the vast scope of relevant historical example, HERO has concentrated on a broad examination of the extent to which historical example could provide one or more useful approaches to methodological development. We have not been unduly concerned either with the comprehensiveness of the supporting analyses, or with detailed consistency between the various component sections of this examination. It is understood that this approach is consistent with the desires of RAC.

We have been gratified, however, that the results of our examination have tended to corroborate analytical findings of earlier HERO studies on the potential relationship of qualitative and quantitative analyses of combat data. This has added greatly to our confidence in the conclusions derived from this particular study effort.

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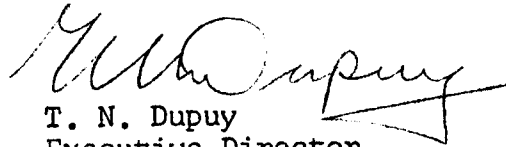
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T. N. Dupuy
Executive Director

Washington, D. C.
17 February 1967

BASIC DEFINITIONS

For the purposes of this study, we established the following basic definitions relating to mobility:

Mobility. The ability of military units to move as effective formations from place to place, to include the ability to support the units logistically during and after movement. Mobility is a relative concept, and should not be equated with any absolute rates of movement or of speed. Mobility is meaningful militarily only in terms of the relative movement capabilities of opposing forces.

Maneuver. The use of mobility to gain positions or to effect combinations of military advantage, or to alter situations which are disadvantageous.

Strategic Mobility. The capability of large military formations to move beyond the limits of the battlefield, or between theaters of operation.

Tactical Mobility. The capability of any military unit to move and maneuver on the battlefield or in the presence of an enemy. This has three distinct aspects: (1) the approach to contact; (2) movement while actively engaged in combat operations; and (3) support of units in combat by: firepower, commitment of reserves, and logistic support.

TACTICAL MOBILITY IN HISTORY

Mongol Mobility

The mobility of Genghis Khan's troops--tactical as well as strategic--has never been matched by other ground soldiery. He seems to have had an instinctive understanding that force is the product of mass and the square of velocity. No other commander in history has been more aware of the fundamental importance of seizing and maintaining the initiative; of always attacking, even when the strategic mission was defensive.

We know little of the details of the training system of Genghis Khan. We do know that each troop, squadron, and regiment was capable of precise performance of a kind of battle drill that formed the basis of Mongol small-unit tactics. Such precision required constant practice under close and demanding supervision. The battlefield coordination of units, within the toumans, and between toumans and the larger hordes, is evidence of painstaking practice in precombat maneuvers by forces of all sizes.

At the outset of a campaign, the Mongol toumans usually advanced rapidly on an extremely broad front, maintaining only courier contact between major elements. When an enemy force was found, it became the objective of all nearby Mongol units. Complete information regarding enemy location, strength, and direction of movement was immediately transmitted to central headquarters, and in turn disseminated to all field units. If the enemy force was small, it was dealt with promptly by the local commanders. If it was too large to be disposed of so readily, the main Mongol army would rapidly concentrate behind an active cavalry screen. Frequently a rapid advance would overwhelm separate sections of an enemy army before its concentration was complete.

Genghis and his able subordinates avoided stereotyped patterns of moving to combat. If the enemy's location were definitely determined, they might lead the bulk of their forces to strike him in the rear, or to turn his flank. Sometimes they would feign a retreat, only to return at the charge on fresh horses.

Most frequently (as in Genghis' operations in Persia, 1220-1221), the Mongols would advance behind their screen of light horsemen in several roughly parallel columns, spread across a wide front. This permitted flexibility, particularly if the enemy were formidable, or if his exact location was not firmly determined. The column encountering the enemy's main force would then hold or retire, depending upon the situation. Meanwhile the others would continue to advance, occupying the country to the enemy's flank and rear. This would usually force him to fall back, to protect his line of communications. The Mongols would then close in to take advantage of any confusion or disorder in the enemy's retirement. This was usually followed by his eventual encirclement and destruction.

The cavalry squadrons, because of their precision, their concerted action, and their amazing mobility, were easily superior to all troops they encountered, even when these were more heavily or better armed, or more numerous. The rapidity of the Mongol movements invariably gave them superiority of force at the decisive point, the ultimate aim of all battle tactics. By seizing the initiative, and exploiting their mobility to the utmost, the Mongol commanders, rather than their foes, almost always selected the point and time of decision.

The battle formation was composed of five lines, each of a single rank, with large intervals between each line. Heavy cavalry comprised the first two lines; the other three were light horsemen. Reconnaissance and screening were carried out in front of these lines by other light cavalry units. As the opposing forces drew nearer to each other, the three rear ranks of light cavalry advanced through intervals in the two heavy lines to shower the enemy with a withering fire of well-aimed javelins and deadly arrows.

The intensive firepower preparation would shake even the staunchest of foes. Sometimes this harassment would scatter the enemy without need for shock action. When the touman commander felt that the enemy had been sufficiently confused by the preparation, the light horsemen would be ordered to retire, and synchronized signals would start the heavy cavalry on its charge.

In addition to combining fire and movement--and missile action with shock action--the Mongols also emphasized maneuver and diversions at all tactical levels and in all phases of combat. During the main engagement, a portion of the force usually held the enemy's attention by frontal attack. While the opposing commander was thus diverted, the main body would deliver a decisive blow on the flank or rear.

In his early campaigns, Genghis Khan's cavalry armies were frequently frustrated by the strong walls of Chinese cities. After intensive, analytical study--plus the adoption of Chinese weapons, equipment, and techniques, and considerable empirical experience--the Mongol leader in a few years developed a system for assaulting fortifications which was well-nigh irresistible. An important component of this system was a large, but mobile, siege train, with missile engines and other equipment carried on wagons and pack animals. Genghis conscripted the best Chinese engineers to comprise the manpower of his siege train. Combining generous terms of service with the compulsion of force, he created a most efficient engineer corps.

Sometimes, however, even the strongest cities were overwhelmed and captured before they were fully aware that any large force of Mongols was in their vicinity. This was particularly exemplified by Subotai's capture of Kiev, December 6, 1240. The leading Mongol light horsemen attempted to pursue defeated enemies so closely and so vigorously as to ride through the gates before these could be closed. Even if the enemy were sufficiently alert to prevent this, he rarely anticipated the speed, efficiency, and vigor with which the Mongol engines of war--ballista and catapult--were put into action within a few minutes of the arrival of the leading cavalry units. The Mongols discovered that a prompt and vigorous assault, covered by a hail of fire from these machines, would often permit them to scale the walls and to seize a portion of the defenses before the surprised enemy was prepared to resist.

Gustavus Adolphus and Tactical Mobility

Most of the extensive modifications in equipment, weapons, and organization introduced by Gustavus Adolphus were for the combined purposes of increasing firepower and enhancing tactical mobility. Usually there were interactions between his efforts to improve both firepower and mobility. For instance, by increasing the rate of fire of his infantry (both by reducing musket weight and by speeding the loading process), he could reduce the number of musketeer ranks from eight or more to six, he could have two, or even three, ranks fire simultaneously, while (instead of remaining stationary as had been the generally adopted Spanish practice) the entire formation moved forward, to provide a kind of infantry small-arms rolling barrage.

Prior to the innovations of Gustavus, cavalry was employed either in the German reiter fashion (relatively slow-moving heavy cavalry, primarily dependent upon pistol firepower), or in the French fashion as a shock action force, whose operations could not be effectively coordinated with the stationary infantry. Gustavus to some extent combined these two methods, for the purpose of achieving close coordination between his more mobile infantry firepower and cavalry shock capability. His cavalry, armed with pistol and saber, was formed in six ranks (later in three). The pistol was a gesture; the real effect came from the saber charge. The first rank fired when it was close to the enemy, the other two held fire, retaining the pistol for emergency use. Detached musketeers stationed between cavalry squadrons provided the firepower that shook the enemy line. While the cavalry charged, the musketeers would reload, to be ready to fire another volley for a second charge or to cover a retreat. Additional firepower was provided by the mobile regimental cannon.

There was one disadvantage to this system: by tying the cavalry to the infantry and artillery, Gustavus sacrificed the speed and momentum of the horse, save for the final distance of the charge. On the other hand, it was better than anything yet devised and, for maneuver purposes, it successfully integrated infantry mobility and firepower with cavalry mobility and shock capability.

The Swedish artillery was organized into permanent regiments of six companies. Of the six companies, four consisted of guns and gunners, one of sappers, and one of men with special exploding devices. Thus, instead of being operated by hired civilian specialists, the artillery was organized as a distinct and regular branch of the army, manned almost entirely by Swedish troops, thus facilitating integration with the other services. After some experimentation Gustavus adopted the 3-pounder "regimental gun," which revolutionized the role of artillery; each regiment of foot and horse in Gustavus' army had one (later two) of these cannon. This assured the availability of mobile firepower with the infantry. The enormous advantage which this provided in battle was soon imitated in other armies.

Most of Gustavus' innovations were adapted from others, and he was not the only one to improve the military system. But no one else so surely bridged the gap between conception and achievement; none other fitted their innovations into a completely integrated system with its own set of unifying principles. His accomplishments were many: by increasing infantry mobility he gave to combined infantry and cavalry the capacity for coordinated

offense; he increased firepower and made it the preliminary for both maneuver and shock--thus enhancing mobility. He made artillery mobile, and integrated it into the combined arms team; by this generally enhanced mobility he made linear formations more flexible and responsive to the commander's will.

The results of these innovations had their first major impact on other European armies at the Battle of Breitenfeld, September 17, 1631. Two days earlier an imperial army of 36,000 men, under Baron Jan Tilly had seized Leipzig. Gustavus, with 26,000 men, joined a Saxon army 16,000 strong at Dübén, 24 miles to the north, and moved against Tilly.

Tilly took a stand at Breitenfeld, four miles north of Leipzig. Under harassing fire from the imperialists, Gustavus drew up his lines with Saxon cavalry, under Elector John George on the left wing, Saxon, Swedish and other German infantry in the center, and his Swedish cavalry on the right wing.

The German left-wing cavalry opened the battle, sweeping around behind the main body of the Swedish cavalry and attacking Gustavus' reserve. The maneuverable Swedish horse wheeled and pinned the German horsemen between them and the reserve, forcing the Germans to flee in disorder. Tilly's right wing meanwhile attacked the Saxons, driving them completely from the field.

This left about 30,000 imperial troops, opposed to 26,000 Swedes. Tilly now attempted to envelop the exposed Swedish left flank. The Swedes, shifting with agility, countered the movement, repulsing the imperial attack. Gustavus then personally led his right-wing cavalry, followed closely by infantry and artillery, around Tilly's left flank, recapturing the Saxon guns as well as the unwieldy imperial artillery, which had been left behind when Tilly attacked. Cut off from their communications to Leipzig, and under fire from their own and the quick-firing Swedish artillery, the imperial army broke and fled when Gustavus pressed home his attack.

The maneuver which won the battle was the direct result of the mobile combined arms capability which Gustavus had created.

Frederick the Great and Mobility

Unlike Gustavus, Frederick the Great made few fundamental changes in tactics, organization, or equipment. His principal

contribution to tactical mobility was to perfect weapons, techniques, and tactics, through intensive training and strict discipline, to achieve a hitherto unknown precision in performance on the battlefield. The result was greater speed in firing--in other words, more firepower--from his infantry and from his artillery, and a greater speed and responsiveness in movement and maneuver, which almost invariably assured him the tactical initiative in combat, even when he was placed at a strategic disadvantage.

Frederick had inherited from his father one of the best-drilled, best-equipped armies in Europe. Frederick improved upon this superb instrument of warfare. His father had reduced the infantry line to three ranks and brought them closer together. Iron ramrods, long in use for pistols, had been adopted for the musket. The men had been trained to fire as many as five rounds a minute, as compared to two in most other armies. The Prussian infantrymen advanced steadily and continuously in step in slow time, firing volleys at intervals on command, starting at 100 paces. The men of the first rank, and later of all three, fired with bayonets fixed. Reduction of the number of ranks and the distance between them made it possible to form a column of march with a front that could be accommodated on an ordinary road. The march column could swiftly be formed into line to the flank, by a simple flank movement, or could deploy into line to the front by a series of half-right and half-left column movements to bring the elements in the rear abreast of those in the van, followed by simple right-angled column movements by each subordinate unit.

The cavalry consisted of cuirassiers, dragoons, and hussars. The first two were organized into 5-squadron regiments, the last into 10-squadron regiments, about 120 men to the squadron. The artillery organization was by battalion, with the customary guns in calibers from 3- to 24-pounders.

For battle the infantry was formed into two lines, about 300 paces apart. The cavalry, formed into two or three lines, was on the flanks. The army was divided into four commands for control; two wings of infantry and two of cavalry. Maneuver by elements was almost impossible once this rigid formation was adopted; neither the organization nor the deployment permitted it. The only way to maneuver, therefore, was to move all or part of the entire army to the oblique, an extremely difficult movement that only Frederick was able to achieve, thanks to the perfection of his drill and the discipline of his troops. The success of the oblique depended also on knowledge of the enemy's dispositions and on surprise to prevent reinforcement of the threatened flank.

Reconnaissance and intelligence were therefore emphasized; and every opportunity that might afford surprise--weather, terrain, etc.--was exploited. An advance guard held the enemy in place to prevent shifts in his line to meet the main attack. The attack itself was characteristically vigorous, fire from infantry and artillery almost continuous.

Under Frederick there was a renewed importance of the shock power of cavalry in battle. Firearms were taken from the horsemen, and they were taught instead to charge at full speed, ignoring the enemy fire, with sword in hand. To enhance mobility, the cavalrymen's equipment was made as light as possible, thus permitting greater speed to increase the fury of the charge. Close order and alignment were achieved by constant drill, and the Prussian cavalry could move with practically the same precision as the infantry. Eight to ten thousand mounted men could charge for hundreds of yards in perfect order, then reform for movement almost immediately. Of 22 battles fought by Frederick, it is said that his cavalry won 15.

Frederick gave his artillery greater mobility so that it could support the hard-riding cavalry and his fast-moving lines of infantry. The Austrian artillery was particularly effective, and he sought to offset the enemy's advantage by the use of horse artillery, which could accompany the cavalry. The cannoneers were individually mounted, instead of going on foot or by wagon. He employed mostly light guns and howitzers that could be moved quickly. These he placed at important points to protect his line and support the advance. In an attack his 3- and 6-pounders dashed out ahead of the infantry. At 500 paces from the enemy, the gunners dismounted, unlimbered their guns, and opened fire at the enemy until the infantry line caught up with them.

The most renowned example of Frederick's tactical mobility and flexibility was the Battle of Leuthen, December 6, 1757.

Prince Charles' Austrian army, nearly 80,000 strong, lay in a five-mile-long line of battle, facing west in undulating country, a few miles from Breslau (Wroclaw). Cavalry protected both flanks. The Austrian reserves lay behind the left wing. Frederick, who had arrived from central Germany after a 12-day forced march of 120 miles, seized the offensive. With 36,000 men he moved toward the Austrian right, in four columns; two infantry columns flanked by two cavalry columns. Under cover of a range of low hills, he changed direction obliquely to the right, leaving his left-hand column of cavalry in his rear, facing the enemy. Still out of sight of the Austrians, the infantry was thus marching past the

enemy front in two parallel columns, half of his cavalry in the lead, half in the rear. Charles, meanwhile, had moved his reserves to bolster his apparently threatened right wing.

When Frederick's marching columns came opposite the Austrian left flank, the king faced his infantry to the left and attacked in two lines, echeloned from the right; the pressure increasing as each successive battalion moved in. At the same time massed Prussian artillery fire shot at the apex of the Austrian left flank, ranged in a vee. The Prussian cavalry on the right flank enveloped and charged into the broken Austrian left and threw it back on the center. Charles attempted to form a new line against this attack, at the same time throwing his right-wing cavalry against the Prussian left flank. But the Austrian horse was caught and scattered by the rear half of Frederick's cavalry, who then charged in on the Austrian right flank. Thus caught off balance, the Austrians never rallied. Nightfall alone enabled the escape of the vanquished across the Schwiednitz River to Breslau.

"Masterpiece of maneuver and resolution," Napoleon later commented. Leuthen is generally considered to be the chef d'oeuvre of the man who was perhaps the ablest tactician of military history.

Tactical Mobility and the American Revolution

In the latter part of the 18th Century, just before and during the American Revolution, two independent but related innovations in warfare had very significant effects on tactical mobility. In the first place, bitter experience in the French and Indian War taught the British (and the French as well) that the tightly packed drillfield formations of European combat were not readily applicable to the forested wilderness of America. The British, therefore, developed a new type of highly disciplined light infantry, more mobile, and capable of fighting effectively in open order formations. The new light infantry was effective in European combat as well, mainly as skirmishers. France and other European nations followed this British example. The Germans, for instance, armed their light infantrymen (whom they called *jäger*s) with rifles, rather than with the ordinary military musket which was the principal military weapon then in use in the English and other armies.

The rifle was the second innovation which affected mobility. This weapon had been invented in the Alpine regions of Germany and Switzerland several centuries earlier. Because of its great range and accuracy it had been regularly used by mountaineer hunters (hence the name jäger). But it had not found favor as a military weapon in Europe. Its advantages in range and accuracy were outweighed by several drawbacks: it was a much more expensive, more complicated weapon; it was considerably heavier; it could not readily be adapted to a bayonet; it could not be as readily standardized as the musket; and it took even longer to load. Its advantages seemed relatively unimportant to 18th-Century European military men, who relied upon muskets to provide concentrated, unaimed volley fire as a preliminary to a climactic and decisive bayonet charge. But for light infantrymen, firing individually instead of in formations, the accuracy and range proved appealing to German military men, and facilitated individual mobility.

In the operations of the American Revolution, neither side had any significant advantage insofar as tactical mobility was concerned. The lessons of the French and Indian War had been well learned by the English and so--despite hallowed American myth--they were as capable of mobile and flexible operation with light infantry in the forested regions of North America as were the colonists. For all practical purposes, furthermore, there were nearly as many colonists fighting for the Loyalist cause as there were on the Revolutionary side.

Strategic mobility played an important part in the final outcome of the American Revolution, but mostly through the military genius of George Washington. On the battlefield more often than not well-trained, highly disciplined British units were at least as mobile as the Americans.

The one campaign where tactical mobility appears to have played a significant part was in the operations of American generals Sullivan and Clinton in northern New York in the late summer of 1779. Here it was evident that the American Continental, as well as the nonregular soldiers of the militia units which served beside them, were at a definite disadvantage in trying to bring the more mobile Indians to bay. Unquestionably the Indians were frightened, and to some extent pacified, by this campaign. On balance, however, its results were quite disappointing, mainly due to the fact that the Continental infantrymen were at a great disadvantage in attempting to pin down the lightly armed and lightly equipped Indians.

Tactical Mobility in the Napoleonic Wars

Napoleon's principal genius in military affairs was strategic. However, he seized upon, exploited, and improved the tactical innovations which had been introduced by Carnot in the Revolutionary period, primarily in the field of mobility. Napoleon personally contributed to tactical mobility in four major respects: organization, infantry tactics, artillery tactics and techniques, and cavalry tactics.

Napoleon enhanced the tactical, as well as the strategical, mobility of his army through organization. The concept of the division had been introduced into the French army before his time. By 1796 the divisional system had become universal in the French army, and a few years later, as the Revolutionary armies began to exceed 200,000 men in size, divisions had been grouped into temporary army corps. In 1804 Napoleon introduced permanent army corps into the French army, employing them as he had previously used divisions in the Italian campaigns. At the same time he improved the divisional system and used it as the basic maneuver unit in tactics of fast maneuver on and off the battlefield. He visualized the division as a task group--primarily of infantry and artillery, but with cavalry frequently attached--to which missions could be assigned, and from which results could be expected.

Napoleon's principal contribution to the battlefield mobility of the infantry division, and later of the army corps, was through his employment of artillery. The French Revolutionary Army had inherited from the monarchy an excellent field artillery system which had been developed by an artillery officer, Jean Baptiste Gribeauval, and introduced into the French army in about 1776. The innovations of Gribeauval were based essentially upon his evaluation of the artillery of Frederick the Great.

The main feature of Gribeauval's artillery was mobility, obtained by reducing the length and weight of the gun barrel, and the weight of the carriage. To enhance mobility, furthermore, the gun carriage was provided with iron axletrees and with wheels of large diameter, facilitating movement over all types of terrain. The range of the guns, and precision of their fire, were preserved despite the reduction of the length and weight of the barrel, by more precise manufacture of the weapon and its projectiles, the balls being true spheres designed to fit very closely into the carefully machined gun barrels. This close fit made possible also a reduction in the powder charge, without any sacrifice in range.

Prefabricated cartridges replaced the earlier practice of using loose powder; this also increased the rate of fire. Draft horses were teamed together into double files, instead of being in single column as previously. Six horses were sufficient to draw the lighter 12-pounder guns, while only four horses were used for smaller field pieces.

Napoleon's cavalry, supported by horse artillery,* and used in great but articulate masses and in surprise operations, was extremely effective. It was usually thrown against the enemy's infantry after the latter had been shaken by massive artillery fire, or by infantry attacks, or was in retreat. French cavalry was less successful against fresh infantry which had the time to form square. Nevertheless, under outstanding leaders and by its impetuous charges, the French horse often proved superior to the best cavalry of other European nations. By its lightning action in pursuit, the French cavalry also spared losses to its own army.

The most dramatic case example of Napoleon's strategic skill was also a prime example of his employment of tactical mobility. This was at Austerlitz, the culmination of one of the most brilliant strategic campaigns in history. In a series of maneuvers beyond the scope of this study, Napoleon had flung himself with an army of about 60,000 men into the midst of a widely scattered group of Austrian and Russian forces, not under adequate centralized control, totalling approximately three times as many as he had available for battle. The principal allied force, approximately 75,000 strong, was enticed into battle on December 1, 1805, under circumstances which appeared favorable to the allies, but which were in fact designed by Napoleon as a tactical trap.

It is clear from the various separate engagements of the Battle of Austerlitz that the French enjoyed no clearcut combat superiority over their Austrian or Russian foes. What gave Napoleon an overwhelming victory in a period of about six hours was the incredible speed with which his infantry moved to attack and rupture the center of the allied line, which had been weakened as it tried to carry out an envelopment which Napoleon had enticingly suggested to them by his dispositions. This was followed by a rapid encirclement of the allied left flank. It

*The technical distinction between highly mobile horse artillery, and somewhat slower horse-drawn artillery should be noted. As instituted by Frederick, every soldier in a horse unit was separately mounted, and no one rode on guns, limbers or caissons.

was the close coordination of rapidly moving French infantry, cavalry, and artillery, superbly trained and well led, and under the direction of a genius of warfare, which gave them superiority over their enemies.

Tactical Mobility in the Mexican War

The principal advantages of the Americans over the Mexicans in the Mexican War were the superior discipline and training of the American soldiers, and a substantial margin of professional competence and skill by American leaders at all levels. The Mexicans fought with a valor and determination which put to shame some American experiences of the War of 1812.

Over and above the general American margin in professional competence was an almost overwhelming American superiority in the tactics and techniques of field artillery. The Battle of Buena Vista provides the clearest demonstration of how the inherent mobility of the American artillery was combined with a firepower superiority which permitted the American infantry also to operate mobilely, while the Mexican infantry was pinned down by the volume of American fire.

In the early stages of a most complicated and disjointed battle, the Mexican numerical superiority brought them success over much of the battlefield. Five of six American Volunteer infantry regiments were put to flight at one time or another. Although they captured two American artillery pieces, the final Mexican advance was held up by magnificent efforts of American Regular artillery which Taylor shifted around the battlefield, then concentrated near the center of his position in order to replace his panicked Volunteer infantry. The gallant Mexican infantry almost reached the guns before they broke under sustained American artillery fire. The one American infantry unit which had survived the earlier phases of the battle (Colonel Jefferson Davis' First Mississippi Volunteers) moved against the left flank of the Mexican infantry held up by Taylor's improvised concentration of artillery in his center. This unexpected flank attack, combined with the artillery fire from the front, drove the Mexicans from the field.

The American Civil War and Tactical Mobility

Too much has been written about the American Civil War to make any effort in this paper to summarize its principal events. The purpose of the following paragraphs, therefore, is simply to indicate how tactical mobility affected the outcome of certain Civil War major engagements.

In general, tactical mobility was less significant in the Civil War than it had been in the Napoleonic era. This was largely due to the greatly increased firepower and range of infantry weapons, which prevented units from approaching each other without prohibitive casualties. Artillery range had not increased proportionally, and thus was also less mobile in the face of long-range infantry fire.

The preliminaries of the Second Battle of Bull Run offer one of the finest examples of strategic mobility in American military history. The actual battle, however, provides some illuminating examples of the use of tactical mobility on both sides. Although the Confederates won the battle, probably there is more profit to be derived from the standpoint of tactical mobility by a study of the movements of Porter's Corps, first in shifting its front and slowing down Longstreet's envelopment, and second by the manner in which Sykes' division established itself as a rearguard covering force, permitting the retirement of the main Federal army.

There is probably no finer example of tactical mobility in all of military history than in the Confederate movements during the Battle of Chancellorsville. The most important, as well as the most dramatic, example was Jackson's envelopment of the Union right flank. But this was only one aspect of the superb disposition and shifting of troops on interior tactical lines, which marked Lee's direction of the battle from beginning to end.

On the other hand, there is probably no clearer example of the ineptitude of leadership in ignoring tactical mobility in battle than that of McClellan at Antietam. Lee, taking advantage of his enemy's poor tactics, was able to shift units rapidly from one portion of the field to another, as needed.

The Vicksburg Campaign is mainly significant because of the superb strategic mobility of Grant's forces. On the other hand, by employing his various units in mutually supporting tactical roles, particularly at the Battle of Champion's Hill, he demonstrated mastery of tactical mobility.

The Battle of Chickamauga is only one of several examples of offsetting ineptitude on the part of higher leadership on both sides during the Civil War. From the standpoint of tactical mobility, however, Longstreet's realization that there was an unexpected gap in the center of the Union line, and his prompt and effective exploitation of this situation, was a splendid demonstration of the understanding of tactical mobility by an alert and aggressive subordinate commander.

The Battle of Chattanooga includes the one major success of assaulting troops against a prepared defensive position in the Civil War. As such, it possibly gave to Grant a false concept of the capability of good troops with high morale in assaulting fortified positions. He was forced to reconsider early the following year during the four weeks between the beginning of the Battle of the Wilderness and the Cold Harbor assault. Nonetheless this Federal success at Chattanooga was directly attributable to maneuver, which in turn was possible because of Grant's mobile tactics.

The operations in Virginia of May and early June 1864, from the Wilderness to Petersburg, demonstrate as clearly as any instances in military history that potential tactical mobility means nothing unless the hostile firepower can be neutralized. Nowhere is the intimate relationship between firepower and mobility more discernable. When frustrated tactically by the Confederate ability to defend prepared positions, Grant had to resort to strategic maneuver to move Lee out of position. When, however, the situation became such that further strategic maneuver was neither profitable nor possible, a stalemate ensued. Here was a clear prototype of the kind of stalemate which was to manifest itself on the Western Front in World War I. The reasons for the two stalemates were not identical, though similar, and are of the utmost significance in any study of tactical mobility.

Tactical Mobility and the Boer War

The relationship between tactical mobility and tactical firepower was again dramatically demonstrated in the Boer War. In formal battle, as well as in guerrilla operations, the Boers typically maintained their mobility through dispersal and by employment of horses as mounts for all of their infantrymen. They were able to exploit this mobility and to maintain moral ascendancy over the British for much of the war, mainly because accurate aimed small-arms fire kept the British pinned down. British

battlefield successes came only after they had realized the necessity for avoiding frontal attacks against Boers' small-arms firepower, and for employing artillery in mass, and disciplined cavalry in large formations on raiding and enveloping maneuvers in a fashion which the relatively untrained and undisciplined Boers could not match.

Tactical Mobility in World War I

From the very outset of World War I it became obvious that the mobility of troops committed to battle was severely inhibited by the firepower capabilities possessed by both sides in the form of small arms, machineguns, and long-range, quick-firing artillery. This was clearly demonstrated at the Battle of the Marne. There were only three instances during that battle in which major forces were able to make any significant advances once the opposing infantry formations had become engaged. Two of these involved night attacks; in one case a night attack by the French Fifth Army against the German Second, and in the other case a night attack by the German Third Army against the French Ninth. But the decisive maneuver of the battle was made by the British Expeditionary Force in moving between the German First and Second armies, a movement which was possible solely because the Germans had no substantial forces between these two armies with which to interfere tactically.

The decisive German victory at the Battle of Tannenburg was accomplished primarily by strategic disposition of German forces and the cooperation of the Russians in moving into the trap which the Germans set for them. The German II Corps, which effectively cut off the retreat of the Russian Second Army, was able to move into position with relatively little opposition. It then was able to hold a thin line across the line of retreat of the Russian Second Army, without any major resort to entrenchments, mainly by firepower.

Tantalizing possibilities of tactical mobility were suggested to the Allies by their use of tanks at the Battle of the Somme in 1916, and at Cambrai in 1917. In both instances, however, the Germans were able to limit the advance of the tanks and then by major infantry counterattacks to recover most of the territory which the tank attacks had gained. True tactical mobility did not return to the battlefield in World War I until the fall of 1917. This was achieved by the Germans, experimenting with their new combat group tactics, in which they combined infiltration and

individual mobility of the infantry soldier with integral automatic weapons fire and close supporting high-explosive fire. This was first demonstrated at Riga, in September 1917, and then at Caporetto in Italy, in October and November of 1917.

The true significance of the German tactical revolution did not become apparent, however, either to the Germans or to the Allies, until the dramatic tactical successes of the first two German offensives in early 1918. These successes suggested that the Germans had discovered the entire secret of ending the tactical stalemate which had been imposed by the combination of trenches, barbed wire, machineguns, and high-explosive artillery fire. On the other hand, these German offensives failed strategically because of German inability to "feed the battle." They were unable to provide adequate infantry reinforcements for exploitation, or adequate supporting artillery fire, or above all adequate logistic support, to their front-line infantry troops. There were still some aspects of tactical mobility eluding the Germans.

The Allied counteroffensives of the summer and fall of 1918 borrowed considerably from the German examples. The Allies had not yet, however, had an opportunity fully to absorb the German lesson, or fully to understand the tactical concept of the combination of mobility and firepower which underlay the German tactical successes. Thus the Allied advances were much less spectacular than those of the Germans. They were achieved essentially because of ability to establish a fundamental firepower superiority over the defending Germans and then to take advantage of this firepower superiority by relatively limited movements all along the front. In this offensive, of course, the Allied advance was aided considerably by the presence of tanks, and to a lesser extent by the availability of a certain amount of direct air support of front-line units.

One of the significant innovations of World War I, comparable in tactical mobility importance to the British introduction of the tank, and the German introduction of the mobile combat group, was the American development of mobile artillery fire support. In the past artillery mobility had been largely the result of being able to move guns rapidly to keep up with advancing infantry and cavalry. As we have seen, the range advantage of artillery, which had permitted significant covering fire for tactical maneuver during the period of the Napoleonic Wars, and even during the Mexican War, disappeared during the American Civil War. And while the range advantage of cannon had been reestablished before World War I, this had not been applied, or indeed even been applicable, in a fashion that related to tactical mobility.

American artillerymen, however, unquestionably led by Major General Charles P. Summerall, who commanded an artillery brigade, an infantry division and later a corps, began to develop the concept of shifting fires of their long-range cannon from one portion of the front to another in a flexible manner completely unprecedented in war. This was a form of mobility in terms of range and direction, for the first time exploiting the greatly elongated ranges of artillery weapons. These innovations of Summerall and other American artillerymen in late 1918 were the forerunners of new American doctrines of flexible and mobile artillery fire support which were to dominate all battlefields on which American forces appeared during the middle of the 20th Century.

There was only one major campaign in World War I in which the traditional forms of military mobility were manifested. This was in the 1917 and 1918 campaigns of the British under General Allenby in Palestine and Syria. There are valuable lessons still to be learned from the manner in which Allenby was able to use his horse cavalry in combination with modern automatic weapons, and artillery and air power, to achieve a high degree of mobility without sacrificing firepower. This campaign probably warrants more study from the standpoint of the relationship of mobility and firepower than has thus far been given to it in military analysis.

Tactical Mobility and World War II

In the years between the world wars, the records of 1918 were examined by the military staffs of all the great powers. But Germany, in particular, undertook a thorough research effort into this experience and related it to current technological advances. From these studies developed a new tactical system. This was based upon the infantry combat team concept which they had developed in 1917-1918, but was elaborated by using armor in mass (while teaming subunits of armor with subunits of infantry), and by providing radically improved tactical air support to supplement and (if necessary in mobile warfare) substitute for artillery. A flexible, decentralized command system permitted them to take full advantage of the flexibility of such combinations. With this doctrine, the tank and the fighter bomber may be said to have been fully assimilated into land warfare. By this assimilation, the Germans solved the problems of firepower and logistical support, and lack of exploitation capability, which had prevented them from achieving success in 1918.

This new tactical system, which the Germans called blitzkrieg, was first revealed to the world in 1939 in the Battle of Poland. But observers of other countries simply disbelieved what they saw. They attributed the German successes to Polish ineptitude, rather than to a revolutionary new German tactical system.

It was in the 1940 campaign in the West that the remainder of the world fully realized the extent of this tactical revolution. Analysis revealed that the key to the German success was not numerical superiority or better tanks, or more airplanes. It was the application of sound and proven military principles, but re-vitalized and applied with a vigor comparable to that which Napoleon had employed nearly a century and a half earlier, and incorporating as a key element the use of tactical mobility on a scale and in a fashion which had not been seen on the battlefield since the time of Genghis Khan.

The eventual successes of the Western Allies against the Germans, in the reconquest of Western Europe and the invasion of Germany, were fundamentally the employment of the new tactical system devised by the Germans, improved in some respects (probably mainly in terms of the employment of tactical air support) but relatively unchanged in its fundamentals.

Perhaps the most interesting example of tactical mobility in large-scale major operations by the Allies against the Germans in France resulted from a bold decision by Major General Lucian Truscott, commanding the VI Corps, in the breakout from the beachhead in southern France in late August 1944.

Truscott, upon landing, realized that the Germans had been completely surprised, and that by evening of D-Day, August 17, he had completely broken through the hasty German beachhead defense. In a prompt and bold decision, he decided to exploit immediately, despite lack of logistical buildup, and despite an acute shortage of vehicles for rapid movement. He created a special task force -- known as Task Force Butler from the name of its commander, Brigadier General Frederick B. Butler -- consisting of an infantry battalion, a cavalry reconnaissance squadron, an armored field artillery battalion, a half-strength tank battalion, and a company of tank destroyers. Making the boldest possible use of this force, Truscott sent them northwest across the spurs of the Basses Alpes, to reach the Rhone Valley at Montelimar. Here the retreating formations of the German Nineteenth Army were struck. In a desperate battle, lasting several days, the bulk of the Nineteenth Army finally escaped, but only because of the long supply lines of Task Force Butler, and the acute shortage of trucks to provide needed supplies to the task force.

Another example of the use of tactical mobility by American forces in Western Europe can be found at the tank battle of Arracourt, in Lorraine, in late September 1944. Here American tanks, outnumbered and inferior in characteristics to the tanks opposing them, inflicted a crushing defeat upon the Germans. There were a number of factors in this American tank victory, but the most important of these was the utilization of tactical mobility by aggressive American leadership.

One of the most interesting historical case studies of tactical mobility in World War II can be found in the German Ardennes offensive of December 1944. The initial success of that offensive was partially due to German exploitation of tactical mobility. The offensive failed, however, because subordinate American commanders recognized the significance of the road net -- and particularly the key communications centers -- to the accomplishment of the German plan. The decisions of these commanders, which resulted in bitter battles at St. Vith and Bastogne, blocked these road centers, and prevented the Germans from carrying out the mobile operations they had envisaged.

Allied forces made three key crossings of the Rhine River early in 1945. On March 7, by a brilliant example of tactical mobility that surprised the German defenders of the Ludendorff Bridge at Remagen, the 9th Armored Division of the First US Army seized the bridge and established a bridgehead on the east bank of the river. On March 23, the British Second Army made an assault crossing of the Rhine, which included an airborne drop near Wesel. This was a carefully planned and meticulously implemented power play, in which firepower and tactical mobility were well coordinated. The day before, however, considerably further south, the American Third Army had crossed the Rhine at Oppenheim, in an equally carefully prepared, but subtle and unexpected operation which surprised the Germans completely. The Oppenheim crossing was one of the best examples of American tactical mobility in World War II.

In the Asian and Pacific war, the first major campaign was a demonstration of the importance of tactical mobility when employed vigorously and boldly. The Japanese forces that conquered Malaya did not have a significant numerical superiority over the British. In fact, the British forces eventually captured by the Japanese by the end of that campaign were more numerous than the entire Japanese invasion force. But, travelling almost completely on foot, utilizing surprise, infiltration, and above all envelopment (including small-scale amphibious envelopment) the Japanese kept

the British completely off balance. This campaign probably warrants considerable study as a case example of tactical mobility.

The American Manila campaign of 1944 was exemplified by the same kind of exploitation of the initiative by tactical mobility which characterized American operations in France during that same year. By a combination of boldness, rapid movement, and the devastating employment of superior firepower, the American troops won a victory more rapid and more one-sided even than that which the Japanese had won in Malaya two and a half years earlier.

The Meiktila campaign in Burma, in May 1945, was a demonstration of the combination of strategic and tactical mobility by British General Slim in a brilliant operation which crushed Japanese resistance in Burma. The seizure of Meiktila, on the line of communications between Japanese main forces in Mandalay and their base at Rangoon, was accomplished by the rapid exploitation of a surprise crossing of the Irrawaddy River. The British, a mixed force of armor and infantry, then deliberately established a perimeter, allowing themselves to be surrounded by the Japanese, while maintained by air supply. They then chewed Japanese counter-attacking forces to pieces with superior firepower and mobile armored counterattack.

Tactical Mobility since World War II

The principal characteristic of the initial North Korean invasion of South Korea was a well-calculated effort to employ tactical mobility to overrun the inferior forces of South Korea before there could be effective American intervention. This almost succeeded, and the remnants of the South Korean army, reinforced by additional American troops rushed from Japan, barely maintained themselves in the Pusan Perimeter. The defense of that bridgehead was perhaps as splendid an example of the use of tactical mobility on the defensive as is available in modern war. It was by exploiting superior mobility that the Americans were able to meet and repel every North Korean counterattack, utilizing interior lines tactically to achieve great superiority of force in practically every engagement.

The breakout from the Pusan Perimeter was achieved more by superiority of firepower than through any other characteristic of the attacking American forces. Once the breakthrough was complete, the exploitation was more of a strategic pursuit than it was a tactical operation.

After the intervention of Chinese forces into the war in November and December of 1950, it became evident to the Americans that there is more to tactical mobility than rapid road movements of tanks and trucks. The Chinese demonstrated, in the same way that the Japanese had done in the Malayan campaign, that aggressive, rapidly marching foot soldiers, utilizing difficult terrain and employing infiltration and small-unit maneuver, are fundamentally tactically more mobile than high-speed forces which through organizational characteristics or mental outlook, are mainly limited to movements and operations in the vicinity of roads. There is some question as to whether American troops ever fully learned this lesson, and it has been evident that some re-learning has been necessary in Vietnam.

The principal superiority evidenced by the Israeli forces over the Egyptians in their Sinai invasion was in terms of tactical mobility. There was no great superiority in numbers, or in equipment. It was the bold and aggressive employment of small task forces and exploitation of fast-moving, well-prepared forces, which gave the Israelis an overwhelming victory. Unquestionably training and morale had much to do with the Israeli success, but these were components of their superior tactical mobility.

HISTORICAL BASIS OF METHODOLOGY
IN RELATING MOBILITY TO COMBAT EFFECTIVENESS

The Concept of Military Mobility

In the light of the spectacular technical developments of the last half-century mobility has come to be equated with speed, especially the speed of mechanized vehicles. This concept, while perhaps a natural one, is surely erroneous. Not only is military mobility not necessarily a function of speed of movement, but the requirements for achievement of speed may often curtail or nullify mobility.

Thus the airplane is, in terms of speed, the most highly mobile of military weapons. But an air force, with its demands for supply, communications, maintenance, and heavy construction, has often been the least mobile of military units. This limited mobility of air forces has, in the past, dictated the location and course of land operations to the exclusion of perhaps more pertinent considerations; for instance, it was this factor which narrowed the choice of landing sites to Salerno in September 1943.

In the attainment of mechanical speed on land the results have been comparable. The more highly mechanized the vehicles and weapons of a military command, the greater become the demands for logistical support in fuel, ammunition, and maintenance. Each such demand for support must be met by creation of supply and repair organizations which, in turn, call for logistical support by other formations with their own requirements for support until the ratio of teeth to tail becomes asymmetrical to the point of absurdity. One tank, carrying its guns and crew into battle at 30 miles an hour, can be dragging behind it several hundred non-combatants, tons of shop equipment, and scores of supply vehicles in which a single malfunction may rob the tank of mobility altogether.

General William T. Sherman, who has provided some memorable examples of the uses of mobility, left a succinct statement of the adverse influences military mobility imposes upon itself. "No

army dependent on wagons," he wrote, "can operate more than a hundred miles from its base, because the teams going and returning consume the contents of their wagons, leaving little or nothing for the maintenance of the men and animals at the front, who are fully employed in fighting."* This constraint, which Sherman alleviated first by use of a railroad and finally by living off the country, is of much greater consequence under modern conditions than Sherman found it. He had to build blockhouses and detach considerable troop strength to guard his line of rail communications, just as lines of communications must be guarded and serviced today by troops who otherwise would be fighting. But the logistical demands of today's weapons and vehicles are exponentially greater than were those of Sherman's time and living off the country is no longer possible except to a very limited extent perhaps in terms of subsistence.

As in everything else in war, mobility is a relative matter, whether it be thought of as rapid movement or as any movement at all. Quite obviously, the speed and power of armor is negated by mud through which it cannot plow or roadless mountains beyond its capacity to climb. Even the soldier on foot is mobile only to the extent that terrain and his own physical state enable him to move; as the German aphorism has it: "My army can attack but it can't go on marching."** There is reason to believe that the US Army today in Vietnam is seriously inhibiting its own mobility with respect to its enemy by overloading soldiers in combat.

In the inexorable relatively of things and conditions in war the only decisive mobility is that of armies, to which the speed and agility of vehicles may contribute but on which it does not necessarily depend. This sort of mobility is maneuver, and it may be negative as well as positive; that is, it may consist in denying mobility to an enemy as much as in attaining mobility for oneself. In this sense, the siege warfare of the Middle Ages was mobility warfare, since the trade which spawned towns dictated their location at the junctions of road systems. An invading army, if it was to use the roads (which it must), had to seize the towns controlling their junctions before it could proceed, resulting in a fight for mobility which all too often, by disease or starvation,

*Robert Underwood Johnson and Clarence Clough Buel, eds., Battles and Leaders of the Civil War. New York: Century Co., 1884-1888, vol. IV, p. 255.

**Quoted in Wilhelm Keitel, The Memoirs of Field-Marshal Keitel (David Irving, tr.). New York: Stein and Day, 1976, p. 152.

so reduced the besieging army that it lost not only mobility but cohesion. Another example of negative mobility is the use of firepower, to pin down an enemy, to prevent or inhibit his movement.

It was the use of mobility for the advantageous maneuver of armies that Nicolo Machiavelli had in mind when he wrote of Césare Borgia that "he reaches a place before anyone knows he is on his way there."* As a rule, the use of mobility in maneuver has been applied by all the great military commanders with a precision almost arithmetical in its simplicity. The force which any one of them was able to bring to a campaign or a battlefield was often dictated by circumstances over which the commander had no control. Whatever its size, it must necessarily be proportionate to the resistance it was to meet. Exact proportion of force to resistance equals stalemate; inadequate proportion of force to resistance equals defeat. The genius of all these commanders was displayed in their use of mobility, in one way or another, to insure a preponderance of force to resistance at a point of decision.

One military virtue these commanders had in common, though few of them ever articulated it, was what Sun Tzu, writing in about 500 BC, called "indirect methods" and B.H. Liddell Hart 24.5 centuries later designated "the strategy of indirect approach."** It means simply the avoidance of head-to-head bull-like combat with whatever enemy appears in one's front and, instead, holding it in position while moving to attack at such a place and in such a manner that it can no longer maintain its opposition. This method requires audacity, imagination, shrewd calculation of the enemy's leadership, thorough planning and, above all, mobility. An apt illustration is the Second Manassas campaign of R.E. Lee in which, with a superior enemy at his rear and a superior enemy building up in his front, he left James Longstreet's corps to fix the enemy in his front while the corps of "Stonewall" Jackson was sent to attack its communications. The result was a battle on ground of Lee's own choosing; and an overwhelming (though incomplete) tactical victory, the sort of victory that results when,

*Legations, II, 15 (26 Jul 1502). The same principle has been enunciated often, including Napoleon's "converge a superior force on the critical point at the critical time," and N.B. Forrest's "get there first with the most."

**The best English translation of Sun Tzu's aphorisms is that of Lionel Giles (1910). For Liddell Hart see his Strategy, New York: Praeger, 1954, passim.

again quoting Sun Tzu, a commander "seeks battle after the battle has been won."

The ingredients of mobility, which will be discussed in some detail below, do include speed. But speed, like the concept of mobility itself, is relative and subject to distinction as well as definition. Thus the three great English victories of the Hundred Years' War, Crécy, Poitiers, and Agincourt, were gained by dismounted forces on the defensive and, except at Poitiers, the major elements were physically immobile. Also, at Crécy and Agincourt the enemy was mounted and armored, as highly mobile physically as it was possible to be at the time. The English achieved a superior effective mobility, however, through their use of missile weapons, accurate and concentrated, which provided an overwhelming ratio of force to resistance by holding the enemy at a distance from which his own weapons could not be brought to bear. At Poitiers, where the enemy chose to attack dismounted, the mobility of missile weapons was extended by 60 mounted English and Gascon knights who fell on a flank of the disorganized French. Had both combatants possessed an equal missile capability, these battles would have depended on maneuver to upset the force-resistance stalemate.

Because of improved means and changing concepts the meaning of military mobility, like those of strategy and tactics, has often been confused, with speed often mistaken for mobility, and mobility being incorrectly equated with maneuver. Quite naturally mobility held one sort of specific meaning when all armies marched on foot, lived largely off the country, and employed weapons demanding bodily contact. Its specific meaning has tended to change with the advent of the internal combustion engine, electronic control of the fires of highly sophisticated artillery, rapid long-range communication, and battles continuing for months at a time over battlefields encompassing thousands of square miles against enemies who may only rarely even be seen. With all of this, the general uses of mobility and the basic principles governing its use do not appear to have undergone significant alterations with time.

The commander who flies his forces onto or within the battlefield, or moves them by truck or armored personnel carrier, does so for the same purposes for which his less well endowed predecessor marched them on foot. It is true enough that high mechanization of armies and their weapons has increased the planning and logistical problems of the commander without really changing them. Men still have to be fed, weapons supplied with ammunition and vehicle power plants with fuel, and men, vehicles, and weapons maintained and repaired and replaced. The differences, which are

relative rather than absolute, are that men must be fed from the rear rather than from the country over which they move; power plants must be supplied with millions of tons of manufactured petroleum rather than with hundreds of tons of hay and oats supplemented by grass growing nearby; ammunition requirements of automatic and other quick-firing weapons exceed anything the soldier of even a century ago could have imagined, and maintenance of both men and matériel has increased not only in proportion to the potential damage infliction of modern munitions and the susceptibility of complex machines to breakdown, but in proportion to the sophistication of maintenance facilities as well. All of this is to say that modern mechanical contributions to mobility carry within themselves inherent limitations on their own performance and these limitations appear to vary directly with the complexity and operational characteristics of the equipment. What the ratio of the actual contribution to mobility of mechanization may be to its potential contribution no doubt is expressible as an equation whose inputs would be derived from theater and battle-field experience and which should indicate areas of possible improvement.

In the literature of war the phrase "maneuver room" or "maneuvering leverage" is frequently encountered. This term describes the requirement for preserving a capacity for mobility whether in defense or attack. It is especially, though by no means exclusively, applicable to beachheads and bridgeheads, which are essentially salients with circumscribed lines of communication and withdrawal and therefore critically subject to successful counterattack until so enlarged that mobility within them may be achieved. But it holds broader and more general meanings. When he set out on his raid into the North in the summer of 1863, General Lee notified Confederate Secretary of War James A. Seddon that one of his purposes was to gain the room for maneuver denied him in his defensive position behind the Rappahannock River.* He achieved the maneuver room he sought, but his failure to make use of it led to his repulse at Gettysburg, where he frittered away his army in a series of uncoordinated frontal attacks against a numerically superior enemy strongly fortified with tactical interior lines.

And finally, in war as in physics, momentum is the product of mass and velocity. So long as both mass and velocity are preserved,

*US War Department, War of the Rebellion, Official Records of the Union and Confederate Armies. Washington: 1881-1901, Series I, Vol XXVII, Part 3, p. 863.

momentum is maintained, and mobility usually is the basic requirement for the preservation of both. The massive frontal attacks of World War I repeatedly failed because the necessary intensive preparation invariably warned the enemy where, and approximately when, they were coming, enabling him to move reserves into position. Then, after the attacking mass had been significantly reduced by fire and velocity lost by difficulties of terrain and tactical obtuseness, the momentum of the attack was dissipated and counterattack by pre-assembled reserves restored the situation.

Qualitative Analysis of Tactical Mobility

The application of tactical mobility in war can be analyzed in terms of categories on a qualitative basis by reference to historical example. As will be noted later, quantitative analysis is also possible, and a relationship can be established between quantitative and qualitative analysis. It is beyond the scope of this feasibility study, and impossible in the brief time available, to attempt a careful correlation here of the two kinds of analyses. In this section, therefore, we shall suggest a general approach to qualitative analysis in terms of certain categories of mobility, such as: speed, logistics, communications, attack, defense, and command mentality as they can be shown to be contributory or relative to military mobility. In a later section we shall briefly show the possibilities of quantitative analysis, and how the two can be related.

Mobility as a Function of Speed

Speed in this discussion will be treated as synonymous with rapidity of movement in terms not only of distance and terrain but of time. In maneuver it is not so important that movement occur at maximum miles an hour but that it be timely relative to the movements of an enemy and that it result in bringing to bear a preponderance of force relative to resistance. Certainly an army equipped with personnel carriers and helicopters can move faster than a force on foot, but in some circumstances, such as guerrilla warfare in terrain suitable to guerrilla tactics, it does not necessarily possess mobility superior to that of the enemy.

In pitched battles, speed of movement alone has rarely if ever been sufficient to achieve the full advantages of mobility. Direction of march relative to the enemy, surprise, timing, deception are all factors which, in association with speed, constitute

mobility. Before Blenheim (1704) Prince Eugene and the Duke of Marlborough were faced with a political necessity for early victory over a Franco-Bavarian army which was forcing dispersal of their force by a threatening dispersal of their own. Eugene and Marlborough compelled the concentration of the enemy by a series of feints. Then, by a night march, when the enemy commander supposed his own concentration would force Eugene and Marlborough to retire, they attacked from an unexpected direction at dawn and gained a complete victory.

The battles of Napoleon I were essentially the culminations of swift and decisive strategic maneuver. By exploiting the mobility of his remarkable armies, which travelled light and lived off the country, Napoleon maneuvered to fall successively on isolated fragments of an enemy force in process of concentrating, thus defeating it in detail. But, as we have seen, he could in battles like Austerlitz gain victory by tactical maneuver.

Since speed is a function of both time and distance, it has been achieved with differing degrees of emphasis on those two factors. For instance, Longstreet rushing to the Wilderness to bolster Lee's sagging flank the morning of May 6, 1864, found his way blocked by other troops crossing his front. Forced to halt, he moved the rear of his command forward so that when it finally was free it marched onto the field two brigades abreast. Although the van of his corps reached the battlefield some 30 minutes late, the rear got there 30 minutes early, cancelling out the delay by the application of mobility in time.

On another occasion, Longstreet's sense of time as equivalent to speed, and firepower as having a dynamic relationship to mobility, served even more spectacularly. After arriving on Jackson's right along the unfinished railway at Second Manassas August 29, 1862, Longstreet was but lightly engaged while Jackson bore the full force of the Union attack. On August 30 Jackson asked Lee for help and Lee ordered Longstreet to send troops from his corps to Jackson's. The order reached Longstreet on a hill between his own left and Jackson's right from which he could see along Jackson's front and down the lines of attacking Union infantry. Quickly calculating the factors of time and space, Longstreet called up Lieutenant Colonel S.D. Lee's battalion of artillery, sited it on the hill, and broke up the Union attack by fire long before he could have formed and moved out the infantry support Jackson sought.

The foregoing examples illustrate factors which apply equally to modern armies with automatic weapons, armor, mechanized transport, fast and accurate artillery, and long-range voice

communications. The ability to move, whatever its magnitude, is relative to everything else on the battlefield and, regardless of inherent speed, constitutes mobility only to the extent that it is used for maneuver and maneuver is directed at critical points. And firepower, whatever its capabilities in range and intensity, does not exist as a factor in battle until it is maneuvered so as to interdict or destroy targets crucial to the course and outcome of the action.

In the spring of 1940 France possessed more and, in some categories, better tanks than did the Germans. The German army employed its armor to gain and maintain a degree of momentum that was disconcerting to the point of demoralization. Its armored thrusts were coordinated with air and artillery fires and operated so as to exploit the rupture they had created by their mass. This the more numerous French armor was unable to do because the doctrine for its employment denied it momentum by failure to multiply its innate velocity by mass.

The tank itself was a product of stalemate war, designed to upset the equipoise of force and resistance which had stultified all productive maneuver. Thus it was designed as an instrument of rupture, geared to infantry tactics and infantry rates of movement, but with a superiority in mobility conferred by its power to cross trenches, plow through barbed wire, and to negate firepower by advancing with impunity against small-arms fire. In addition to doctrine, it was tied to the pace and range of infantry by its own mechanical and technical limitations.

Between the world wars the mechanical reliability and speed of armor were greatly improved and, most importantly, voice radio was developed, making possible command control of tanks in mass and coordination of their supporting arms. Tank firepower was not greatly improved, except in Russia, and the notion of armor as an auxiliary to infantry persisted even in Germany until the spring of 1940. As a result of a series of map maneuvers and experience in Poland, mass and velocity were combined and armor was permitted to exploit its own ruptures, with results which at the time were little short of fantastic.

Yet, for all their speed and momentum, the mobility of large armored commands in battle appears generally comparable to that of infantry armies and, after about 25 days and 250 miles, to decline relative to the latter.* This decline seems to be a function of

*Cf. Marshall Andrews, ORO-TP-10, Rates of Advance in Land Attack against Unprepared Forces (U). Bethesda, Md: JHU-ORO, 1960.

mechanical wear and tear and crew exhaustion, although large armored forces (e.g., Russians in July 1941, Rommel at Alam Halfa in October 1942, Patton in September 1944) have on occasion been stopped dead by lack of fuel. In the case of the Russians, large numbers of tanks were overrun and captured by the advancing Germans.

Technical advances contributing to the power, speed, fire-power, fire accuracy, and other such attributes of armor tend, in the long run, to affect values in tank vs. tank combat. They do not necessarily increase the value of armor as a military arm so long as the tactical requirements and capabilities of armor are observed and exploited by both combatants. This is to repeat, in other terms, the invariable relatively of things in war; any bilateral increase in individual weapon power within accepted tactical contexts merely increases total speed and range and explosive effect without fundamentally altering expectations of military outcomes.

It is demonstrably true that mechanical superiority, adequately exploited, can produce individual tactical superiority of one tank over another, just as it can effect that of one rifle, artillery piece, airplane, or cargo truck over another. Repeatedly in World War II tank speed compensated for gun superiority in an enemy tank and the US mechanically traversed turret enabled the inferior armament of the M4 tank to engage successfully the more powerfully gunned Mark IV and Mark VI Panzers. But these considerations are incidental to the greater area of mobility as applied to armies and of maneuver as a function of mobility.

What is of real concern here, and surely merits investigation in detail and in depth, is the probable effect on maneuverability, and consequently on tactics, of technical advances since World War II in cross-country mobility of armor and the introduction of auxiliary combat vehicles of high mobility across country. What would have been the outcome if, for instance, the German army had possessed fully tracked armored personnel carriers (APCs) in France in 1940 and in Russia in 1941? In both campaigns, exploitation of armored thrusts was restricted by the inability of infantry, artillery, and engineers to maintain the pace of the armored sweeps. What would have been the effect of amphibious tanks and amphibious APCs at the numerous stream crossings in both campaigns whose passage was always excessively costly in time and attrition? The same questions are raised by many other German as well as Allied operations employing armor in exploitation.

Mobility as a Function of Logistics

In the preceding section the self-imposed logistical constraints on mechanized combat and supporting equipment have been generally discussed. US armies have fought all their wars under severe logistical handicaps, five of them at the ends of long and vulnerable seaborne lines of communication, and three in their own territory then badly roaded and, over large areas, lacking roads altogether. In its last war on this continent, the American Civil War, the army effectively used the railroad for strategic maneuver, logistical support, and planning to the extent that all of its major campaigns were directed along the lines of railways. As a British student of warfare has observed, ". . . such were the conditions under which the War of Secession in the United States was fought that without the help of the railways it could not have been fought at all."*

The effective contribution of the railroad in the American Civil War and afterward was mainly strategic, moving and supplying forces in and between theaters. Today's problem, with the intensive mechanization of armies and their battlefield employment of automatic weapons and motorized vehicles, is as much tactical as strategic. Not only must fuel and ammunition be transported in enormous quantities into and throughout theaters; they must now be supplied on the battlefield, in the presence of the enemy, to dispersed commands, and at minimum loss of time and combat effectiveness, together with adequate replacement of the material consumed by modern battle. Maintenance of weapons and vehicles must be accomplished between periods of high combat intensity and repair and replacement of those severely damaged must be as near the battlefield as possible.

Thus the tactical logistical requirements of mechanized armies have become almost as great proportionally as, and greater quantitatively than, were the strategic requirements of the past. Means to meet this demand were devised during World War II which proved less than adequate to the steadily and sometimes dramatically increasing urgencies of that conflict. No standards and no precedents existed before the war upon which realistic planning

*Edwin A. Pratt, The Rise of Rail Power in War and Conquest, 1833-1914. London: King, 1915, p. 14.

could be based, so that responses to unforeseen demands were usually local expedients of less than consistent effectiveness.

Sufficient experience with the tactical logistics of mechanized forces has now been gained to justify some assurance in calculating its probable requirements and devising ways to fulfill them. The crux of the whole problem is time, and time here is a function of mobility and distance. What may be needed is a land approximation of the Navy's fleet trains; that is, a family of fully tracked, lightly armored supply vehicles to accompany mechanized forces to the edge of the battlefield, prepared to move in with ammunition, fuel, rations, and light repair facilities at night or during any lull in combat.

No vehicle specifically designed for the suggested mission is known to exist at this time. Nevertheless its potential effectiveness, and that of the tactical logistical concept, can readily be studied by assigning APCs, with known performance characteristics, to the supply role in any number of World War II battles on which operational data exist and in which tactical logistics is known to have been an important or controlling factor. In none of these actions would the actual tactical concept or its application, or the numbers and types of arms and combat vehicles be changed. The only change would be to provide them with mobile bases capable of matching their own speed and range in tactical maneuver.

In any such exercise it would be assumed that the flow of materials to base ports and along the lines of communication to railhead or truckhead was adequate to the requirements of the tactical situation under study.

Mobility as a Function of Communications

In all battles of which anything is known, adequate communication vertically and laterally has been essential to command and tactical cohesion. For many centuries armies were small enough*, sufficiently compact tactically, and so limited in movement that

*The million-man armies of Herodotus and his successors have not been forgotten but have been dismissed as absurd in the light of probability. To mention only one consideration, the country in which they operated could not have subsisted a major fragment of a million men for one day.

the commander had them under his eye at all times and could readily communicate his orders by voice, courier, horn, gong, or flag. Even before general mechanization, armies had been forced to adopt some degree of tactical dispersion by the intensity of artillery and automatic weapon fires that could be brought against them. Mechanization not only has made even wider dispersion possible but has done a good deal to enforce dispersion. This combined capability and requirement is a function not only of the mobility of combat vehicles but of their ability to cover extensive ground with their weapons and to afford mutual support from widely separated positions.

Therefore, until the development of voice radio in the 1920s and its improvement and the progressive compression of its components during the next decade, there was no accepted means of maintaining command control despite wide dispersion and rapid movement. Prior to the introduction of voice radio, doctrine for control of tanks on the battlefield presented the somewhat ludicrous spectacle of a man on foot going ahead of them with a signal flag.

Current means of communication appear adequate to foreseeable requirements. On the negative side there is the danger of so great proliferation of radio and radar signals on the battlefield that all communication becomes impossible. Perhaps that eventuality would bring back the man with his flag and thus curtail rather than improve mechanized mobility.

There also is another danger, best expressed in the words of British officer writing of his experiences with troops in the Boxer Rebellion in China in 1900:

"Everybody was in a desperate plight, but because nobody had any means of telling anybody else how ghastly everything was, it all ended happily. Half a dozen efficient wireless transmitters would have brought about a catastrophe."*

Mobility in Attack

From the inception of organized warfare mobility has been the essential ingredient of attack. Without mobility, in the sense of

*Col. Peter Fleming, "Unorthodox Warfare," The Journal of the Royal United Services Institution, vol. CIV, No. 616, Nov. 1959.

maneuver, attack is impossible; somehow, at some time, the attacking force must bring the enemy within range of its weapons, hold him there, and maneuver so as to crush or penetrate his front or achieve an envelopment. As attack dictates maneuver, so does the ability to maneuver establish the number and kinds of tactical options available.

The three basic options stated above (crushing, penetration, and envelopment) constitute the only possible methods of attack. But mobility confers on the attacker not only the choice of options, but the capability of combining or converting them so as to create what are in effect alternative options. Frontal (crushing) attack may be used to fix an enemy while another part of the attacking force moves to envelop one or both flanks. This is the basic maneuver employed today from squad to field army, in which a "base of fire" is established by some part of the force, and a "maneuver element" seeks a flank. In the squad the base of fire is an automatic rifle or a machine gun; in the field army it may be a division or a corps; the effect is the same.

The classic example of tactical envelopment was that of Hannibal at Cannae (216 BC), who withdrew his center so that the Roman army, expecting victory, pressed forward until it could be enveloped by Hannibal's wings. This concept of massive envelopment leading to encirclement of an entire army was adopted by Count von Schlieffen in his famous and brilliant plan for operations against France.

Frontal attack or penetration may be employed to create flanks which may then be enveloped. Alexander at Arbela, Napoleon at Austerlitz, Longstreet at Chickamauga and von Kleist in France all used penetration to create interior flanks which were then enveloped. Alexander achieved his maneuver with infantry armed with spears and short swords; Napoleon's penetration was by infantry armed with the muzzle-loading flintlock musket; Longstreet's was by troops using muzzle-loading percussion-lock muskets; von Kleist's was done with armor at high speed and in great depth. All used the same tactical concept with comparable results.

Tactical ideas have changed not only with progress in arms but with changing modes of thought. In such cases return to ancient concepts often has appeared as an innovation and, as far as results are concerned, amounted to innovation. By the time Frederick II of Prussia came on the scene, battlefield tactics had degenerated into little better than a military minuet. Armies spent most of the day carefully forming within musket shot of each other, meticulously dressing their lines, and sounding spirited fanfares on drums and fifes. Then, usually with considerable ceremony, one

attacked and the other defended and after a frequently bloody and unimaginative exchange of fire, one or the other charged with the bayonet (sometimes with cavalry help) and one or the other left the field.

To Frederick all this appeared the nonsense it was. He developed the "oblique attack;" based upon a capability to perform intricate drill field evolutions on the battlefield. His maneuvering from column into line and back into column and from line or column into square and back again demanded precision in drill which his contemporaries noted and mistook for the secret of Frederick the Great's tactical successes. By imitating his drill but not his concept they bogged themselves deeper in immobility from which the undrilled but enthusiastic armies of revolutionary France finally began to force them to lift themselves.

Mobility in Defense

Defense ordinarily is not a strategically decisive posture, although it has led often to tactical success. From the doctrinal viewpoint defense has its uses principally when a weak force must engage a strong force, as a preliminary to attack to gain time because of temporary weakness, or as a diversionary or holding operation prior to or during attack elsewhere. As a holding operation it must be sufficiently vigorous to convince the enemy that it is a genuine defense of position.

When designed to cope with a stronger force against which attack appears hopeless or prohibitively risky, defense can be static, especially if conducted behind fortifications. Lee's defense of Fredericksburg (1862) was tactically decisive but strategically worthless since the Union army maintained its communications intact and simply retired behind a river in its front and remained confronting Lee and threatening Richmond. General George G. Meade's successful static defense at Gettysburg (1863) was strategically effective because Lee had a river at his back and exposed lines of communication upon which he had to retire to protect them. The victory was not strategically decisive because Meade did not use his inherent mobility to counterattack, pursue, and destroy Lee's army before it got safely back across the Potomac.

Flexibility in defense can contribute to its success and go far toward endowing it with strategic as well as tactical significance. Examples of the first are Lee's defense at Antietam where McClellan's piecemeal thrusts across Antietam Creek enabled Lee to shift strength to meet successive attacks; and General W.H. Walker's defense of the Pusan perimeter in which mobility was

employed not only to fend off piecemeal attacks but to launch diversionary counterattacks.

Both examples cited represent improvisations in response to contingencies. Planned flexibility in defense, using mobility deliberately not only to absorb attack but to establish the base for decisive attack has been common. Lee, again, in 1862 had a defensive position constructed on the south bank of the North Anna River between Fredericksburg and Richmond with the purpose of using it as a key to a strategic success. It was in the form of an open-based triangle with its apex on the river between the only two crossings of the stream which were three miles apart. Once an enemy had crossed the river it would be in two parts, each out of supporting distance of the other and confronting a heavily fortified position. By using tactical interior lines the defending force could attack and probably defeat the separated parts of the enemy in detail. Lee intended luring General A.E. Burnside into this trap instead of meeting him at Fredericksburg in 1862 but was required by President Jefferson Davis to defend the city instead. A defeat on the North Anna, with two rivers at his back and his communications insecure, could well have led to a strategic as well as a tactical repulse of Burnside. Some historians suggest that Grant did walk into the same trap in 1864, but that Lee, suffering a heart attack, was forced to let him escape when Grant realized his predicament.

In July 1918 General Henri Gouraud, knowing an attack was coming in the Champagne region east of Reims, prepared for it by withdrawing his troops, except for a few volunteer machine gunners, from his front lines and allowing the Germans to expend their momentum in a military vacuum. Heavy artillery concentrations were laid on the German infantry as it left its trenches and followed it through the abandoned area. A powerful counterattack met the Germans after they had passed Gouraud's front lines, and the stage was set for the final offensive some two weeks later. Gouraud, however, was merely adapting and improving on German concepts of defense in depth demonstrated in earlier campaigns.

The flexible defense in depth, trading space for time, destroying the attacker's momentum by fire, counterattacking on choice, and falling on the enemy in the end with fresh forces, had become standard doctrine. It was used with outstanding success by UN forces in Korea in 1951, invariably being followed by resumption of the general offensive at minimum cost and with maximum effect. The key to flexible defense in depth is mobility translated into fire and maneuver and, with reasonably adequate forces, it is virtually impregnable to frontal attack.

Mental Mobility

Mental mobility may be described as a combination of intellectual vigor, imagination, flexibility, and technical competence. It has been outstanding in all the great captains of all times and, in an age of great physical mobility, is an absolute requisite to success in battle and in war.

Just as the most powerful automobile is of no use whatever in the absence of someone who knows how to drive it, so an inherently mobile military force is actually mobile only to the extent that its commander understands and appreciates the uses of mobility. Guderians, Rommels, and Pattons squeeze the last possible ounce of performance from mobile forces because they think in terms of momentum, of the product of mass and velocity, of multiplying fire by movement.

In modern warfare with its wide dispersion (which is apt to be even wider under the threat of nuclear attack) and its sudden confrontations of commanders at all echelons with unexpected situations, mental mobility must be an attribute of all commanders down to the squad. Again history contains many examples of the failure of command plans and combinations because some subordinate leader lacked the mental mobility of his superior.

Quantitative Analysis of Tactical Mobility

Theoretical Lethality Indices

In a study for the Army's Combat Developments Command, "Historical Trends Related to Weapon Lethality," in 1964 HERO developed a method of evaluating the relative lethality of weapons, regardless of type, by means of "theoretical lethality indices." In the process of that study, these indices were calculated and applied to various weapons and combinations of weapons in operations from the Napoleonic Wars through World War II. The results were sufficiently reasonable and consistent as to give confidence in the method of producing these lethality indices. Accordingly these have subsequently been used as a basis for firepower evaluations in a study for RAC entitled: "Average Casualty Rates for War Games, Based on Historical Combat Data."

In the development of these lethality indices, several factors were considered: rate of fire, number of potential targets per

strike, relative incapacitating effect of each strike, effective range of the weapon, its accuracy, its reliability, its battlefield mobility (where applicable), and its fighting machine capability (for machines such as tanks or combat aircraft). An extensive discussion of the concept for developing the indices, and for applying these factors, may be found in Annex III-H of the study, "Historical Trends Related to Weapon Lethality."

Relationship of Lethality, Dispersion and Mobility

The most significant aspect of the theoretical lethality indices which emerged from that study, and which is also most pertinent to this study, was the fact that the indices facilitated efforts to relate the firepower of weapons (as expressed in terms of the theoretical lethality index) to dispersion and mobility. Applying the theoretical lethality indices to actual combat data of results supported the hypothesis that there is a dynamic and quantifiable relationship between firepower, dispersion, and mobility.

In essence, on the basis of historical combat data, HERO compared "type" (or average) armies or army corps of 100,000 men each for the Napoleonic, Civil, and First and Second World Wars, in terms of (a) the density and shape of deployments; (b) the speed with which reserves could be committed; and (c) total lethality indices for each force, derived by adding the individual lethality indices for each major type of weapon. The results of this comparison are shown in Appendix B.

From our study of history, we know that the major weapons of the time had been fully assimilated in both the Napoleonic Wars and World War II. We also know that new, unassimilated weapons of previously unexpected lethality had frustrated commanders in the Civil and First World Wars and had resulted in heavy casualties as well as tactical and strategic stalemate. Because of this, we were struck by the close consistency in the relationship between dispersion and lethality in the Napoleonic and Second World Wars, and the great differences and inconsistencies in these relationships for the Civil War and World War I. Dispersion is seen to be much less (as it was in historical fact) in proportion to lethality in both of those wars than it was in the Napoleonic Wars and World War II.

Highly significant was the indication that dispersion in World War I, slight though it was in relation to lethality, was at the same time too great for the available means for committing

corps reserves. Lethality had obviously far outrun mobility for that war, a situation rectified by World War II. From the combination of inadequate dispersal in terms of lethality, and excessive dispersal in terms of mobility, in World War I we can clearly see: (a) how a stalemate resulted, (b) why it was so difficult to achieve a tactical breakthrough, and (c) how, once a breakthrough was made, it could not be stopped until it faltered due to its own lack of logistical means.

We stressed that limitations on time and effort in that study precluded the kind of intensive corroboration which is essential before unquestioning acceptance of the hypotheses which emerged. It is, however, most significant to the objectives of this study that these hypotheses were as follows:

1. A combat force should be so dispersed that it occupies an area (in square miles) at least as large as the value of its composite lethality index (in millions); and
2. A combat force should be so concentrated that its reserves can be committed effectively to any part of its area within a fixed period of time, which is probably about four hours.

We believe that, regardless of the outcome, an intensive examination of these hypotheses will contribute substantially to the development of a suitable methodology for relating mobility to combat effectiveness.

Quantifying Other Ground Combat Factors

A parallel line of investigation has been suggested by the results of another HERO study performed for RAC: "Historical Analysis of Wartime Replacement Requirements; Experience for Selected Major Items of Combat Equipment." In the process of that study HERO investigated the possibility of quantifying such variables and imponderables of combat as: intensity of conflict, terrain difficulty, meteorological conditions, experience of troops. No attempt was made to quantify overall combat effectiveness or leadership (obviously a component of combat effectiveness), or the influence of time on combat operations.

HERO came to the conclusion in that study that no specific or precise values can be produced which will permit the generalized quantification of any of these imponderables or variables. On the other hand, the results led us to believe that it will be possible to produce a range of values for these various influences, which

can then be applied in differing circumstances with the conditioning effect of historical judgment. We concluded the study with these words, which we believe are particularly pertinent to this study: "The historian and the analyst, working together, should then be able to develop computer inputs which would give proper weights to the combinations of circumstances which are unique to every battle."

Principles of Tactical Mobility

The Employment of Mobility

From the beginning of history, mobility has been one of the principal sources of success in combat. The ability to use mobility for maneuver is above all a conceptual attribute of mind, and it has distinguished the great captains of all times. As an intellectual quality it is ageless and has been virtually unchanging, and for that reason, study of ways in which commanders of the past have used mobility is still necessary and instructive.

We are not prepared to assert that there are any principles of tactical mobility, or of mobility in general, which differ from the fundamental principles of war. The historical data and analytical discussions in the preceding pages, however, do suggest to us that there are probably a number of relatively immutable factors which determine, or affect, mobility, and which thus bear to mobility a relationship at least comparable to that of the principles of war to general combat capabilities.

In the time available for this study it has not been possible to establish to our complete satisfaction that the factors listed below are all of those which are fundamentally relevant to tactical mobility, or indeed that these are all truly immutable factors or principles. We are satisfied, however, that these are the kinds of factors or principles which need to be isolated in the development of an effective methodology for equating tactical mobility to combat effectiveness, in quantitative as well as qualitative terms.

In consideration of each of the factors, or principles, discussed below, it is essential to bear in mind the four basic definitions of mobility set forth earlier in the study. In particular, the relative nature of mobility must be borne in mind at all times.

Physical Mobility

Physical mobility is the capability of a force to move or to displace effectively in relation to, or in comparison with, a hostile force. Physical mobility is a reflection of the employment of available physical means of movement by a military force, whether this be by foot, by horse, by motor vehicle, by vessel, by aircraft, or other motive means.

Mental Mobility

Mental mobility is determined by the intellectual flexibility of leadership, and the speed of its decisions in terms of the individual commander or staff officer, and in terms of the responsiveness of the staff system.

Doctrinal Mobility

Doctrinal mobility is determined by the country's military doctrine, tactics and techniques, and the degree to which these provide for the use and practice of mobility.

Command and Control Mobility

Command and control mobility presupposes the presence of mental and doctrinal mobility, and the ability of leadership to make correct decisions and effectively to translate them into action. It requires, however, the availability in adequate numbers of effective modern communications means that are quick and reliable, and that themselves possess sufficient range and physical mobility.

Military Intelligence Considerations

Military intelligence geared to the requirements of mobile warfare is a basic condition of command and control mobility. Intelligence must be continuous, accurate, and comprehensive, and its results must be translated in time to commanders at all levels.

Firepower Considerations

Firepower is clearly one of the great determinants of mobility. The capability for rapidly moving troops into combat, and during battle is closely connected with firepower. The availability of highly mobile and effective means of firepower is essential to the mobility of modern ground forces, because without these means the fastest force can be stopped by hostile fire and its potential mobility nullified. Thus mobility is affected by firepower positively in enhancing the movement capabilities of friendly forces, as well as negatively in inhibiting the movement capabilities of hostile forces. In concrete terms it is the ability to inhibit enemy movement by destruction or neutralization (i.e., the threat of destruction), and to enhance the movement of friendly forces by reducing the enemy's ability to interfere.

Exploitation of Terrain

Like firepower, exploitation of terrain has positive and negative aspects. Positive exploitation of terrain means its utilization to facilitate maneuver, either by rapid movement, by concealment, or by overcoming natural or artificial obstacles. Negative exploitation of terrain is its use to deny or inhibit the enemy's ability to move or maneuver by interposing natural or artificial obstacles, or by enhancing available firepower capabilities.

Summation

Mobility has always played an important role in every phase of combat: in approach, attack or defense, and pursuit or retreat. Any increases of physical mobility or firepower, therefore, have strongly affected all phases of modern combat.

In both attack and defense, modern mobility and firepower have increased the opportunity for maneuver, which can be effectively employed not only by the attack, but also in an active defense. At the same time, due to the high lethality of modern weapons and consequent heavy consumption of manpower and munitions, both opponents face the cardinal problem of "feeding the battle," i.e. continuously bringing replacements and supplies, usually under the enemy's long-range fire. The flow of new units or replacements from the rear may also be required by continuing maneuver, or by exploitation of a breakthrough. These problems were not adequately solved until modern mobility means became available.

It is noteworthy, however, that neither enhanced mobility or firepower have changed the nature of military maneuver which - now as in the past - is carried out in the form of penetration, envelopment or encirclement, and exploitation or pursuit.

AN APPROACH TO HISTORICAL ANALYSIS

General

In the development of a methodology based upon historical research it will be necessary first to undertake an intensive effort to carry to conclusion, to refine, and to correlate fully the conceptual approaches to quantitative and qualitative analysis discussed in the preceding section of this study. The next step will be to analyze a number of major engagements of military history in qualitative, and then in quantitative terms. In Annex III-H of its study on Historical Trends Related to Weapon Lethality HERO has suggested a promising approach to the quantitative problem.

However, in the light of the conceptual discussion earlier in this study, we believe that an important preliminary to such efforts at quantification must be a clear definition of the major qualitative considerations related to mobility in principle or categories. In the preceding section we have shown how such principles or categories can be developed. In this section we shall indicate how the qualitative analysis can be undertaken, regardless of what analytic categories should be finally established. For this purpose we have outlined below a preliminary and general analytical approach to some selected historical examples in terms of the kinds of categories which may be developed.

Palestine Campaign - 1918

Situation

The problem on the Western Front in World War I was a high ratio of defensive combat power to space. This resulted in a strongly-held continuous front running from Switzerland to the English Channel and thus left no open flank for maneuver. Defensive combat power in the form of defensive artillery barrages,

interlocking bands of machinegun fire (both of which covered thick barbed wire obstacles), plus adequate reserves predominated over offensive capability, and thus prevented breakthroughs which would open up interior flanks. These factors, fortunately for mobile warfare, were absent in Palestine in 1918.

In September 1918 a British Army (including substantial contingents of Indian, Australian, and New Zealand troops as well as smaller numbers of French and others) comprising about 65,000 fighting effectives, faced about 35,000 effective Turks and Germans on a 75-mile front stretching from the Mediterranean Sea to the upper end of the Dead Sea just north of the Jaffa-Jerusalem line. The major terrain features in the combat zone included the coastal plain of Sharon running north of Haifa bounded on the north by the Mount Carmel ridge, and on the east by the Judean Hills, which extended eastward to the Jordan Valley. Mount Carmel ran inland parallel to the front and behind it lay the plain of Esdraelon which ran from Haifa to the Jordan River valley from which extended strategic routes to Damascus 150 miles away and Aleppo, another 200 miles into Syria.

In a series of actions and feints on the Jerusalem-Damascus axis across the hills towards the Jordan valley and the important rail junction of Deraa on the Damascus-Hejaz Railway during the first half of 1918 the Turks were led to believe that Deraa was the British objective and placed the bulk of their forces to defend along this axis. Deraa was in fact a British objective, but it was not planned to approach it by such direct action.

General Allenby's plan was to avoid the rugged, easily defended Judean Hills and to attack north along the coastal plain, penetrate the Turkish weakened right flank, launch his mobile troops through the gap, seize the passes through the Mount Carmel ridge 30 miles behind the front, and enter the strategic plain of Esdraelon from which the bulk of the Turkish forces would be cut off and the positions protecting the approaches to Syria rendered untenable.

Excellent deception and counter-intelligence prevented the Turks from learning of the concentration against their weak right and the attack launched on 19 September caught them by surprise. In 36 hours the plain of Esdraelon had been seized and those elements of the Turkish armies which had not been killed or captured were in full and confused retreat.

Damascus was reached by 30 September, Aleppo by 28 October, and the Turks sued for an armistice on 31 October. In six weeks

Allenby's army had captured 72,000 Turks, 4,000 Germans and 360 guns and had moved the front forward 350 miles with its own casualties but 5,000. To accomplish this one cavalry division had covered over 550 miles in 38 days. This has been hailed as one of the greatest exploits of horsed cavalry in history, and its last large scale success.

Physical Mobility

British: Strategic logistics had been assured by pushing a railroad and water pipeline from Egypt behind the advancing front during 1916 to 1918. This was supplemented by landing supplies from the sea, especially as the advance moved north along the coast beyond the railhead. The advance beyond the September 1918 front was designed with the capture of railroads as an important objective. These were the railroad running north up the coastal plain and connecting with the Haifa-Deraa lateral which connected with the inland Aleppo-Damascus-Hejaz railroad at Deraa. Railroad engineer battalions were made available to repair and operate these roads without which the advance of 350 miles could not have been reinforced nor supported logistically. The railroad was the long range heavy carrier, with motor transport and horsedrawn vehicles supplying troops from the advancing railheads.

For tactical operations Allenby had two mobile arms; the Desert Mounted Corps of three cavalry divisions (British, Indian, Australian, New Zealand) and an air force which had gained air superiority and was able to concentrate on reconnaissance and interdiction. A measure of the cavalry's efficiency and effectiveness is the 4th Division's riding and fighting over a distance of 75 miles in the first 34 hours of the battle with the loss of only 26 horses foundered as march casualties.

Turkish: Poor Turkish logistic arrangements greatly hampered mobility. Railroad maintenance had low priority and local wood had to be used for fuel which accounts for the denuding of Palestine's hills which are only now being reforested by the Israelis. Proper forage was scarce for cavalry horses and draft animals as was food and medical attention for troops and POL for motor vehicles. British air attacks on roads and railroads further hampered movement.

Comment: The Turks were virtually immobilized through lack of the physical means of mobility as well as relative deficiencies in the other elements of mobility. On the other hand, the British possessed all the means of physical mobility in both the absolute and relative sense to insure success.

Mental Mobility

British: The leaders from Allenby down were either cavalrymen or were keenly aware of the proper employment of the mobile arm and were anxious to execute the breakthrough and cavalry exploitation which was theoretically possible and strategically desirable, but which had never been successful on the Western Front. Even the commanders of the two breakthrough infantry divisions had been cavalrymen and knew precisely the preparations and timing required for the cavalry to be successfully launched. Mobile units and formations at every echelon were pressed forward by their commanders in the finest tradition of the cavalry arm. Once the Turks were off balance they were kept reeling back and successful mounted attacks by day and night against machinegun equipped rear guards were not uncommon. Allenby, himself a cavalryman of wide experience from troop to cavalry corps commander, pushed men and horses of the cavalry as well as other arms and supporting services to the extreme limits of endurance. He had calculated well the relative effectiveness of the two forces and had determined that such a pursuit was feasible against the disorganized and disintegrating Turks.

Turkish: Morale and mental and physical vitality must have been at a low ebb; they reacted and moved sluggishly. The only successful rear guard action and retreat was by elements under Kemel Pasha (who later as Kemel Ataturk founded the modern Turkish republic) together with some attached Germans. For example, the 4th British Cavalry Division during the night exploitation missed Musmus pass through the Mount Carmel ridge and lost time in the hills looking for it. Eventually, through determination and vigor it was found and traversed and the plain of Esdraelon entered. On the plain the leading regiment, 2d Bengal Lancers, encountered a Turkish infantry battalion on the move to defend the pass. It was immediately charged with the lance, surprised, and, after 50 had been speared, surrendered. The cost was one Indian casualty. The Turks had been alerted and ordered to the pass in plenty of time to reach it before the delayed 4th Cavalry Division but the Turkish commander was a sluggard and got underway slowly while the British commander was swift and tireless in getting to the hills, finding the hidden pass, and getting through it.

Comment: The marked contrast in level of mental mobility along with the disparity in the other elements of mobility contributed to the decisiveness of this battle.

Mobile Doctrine and Organization

British: The theoretical aspects of a breakthrough of a defended front and exploitation by cavalry had been worked out doctrinally and organizationally although never successfully executed. Conditions in Palestine made successful execution a possibility which was recognized by Allenby as the cheapest and quickest way to end the war in that theater.

Turkish: A doctrine of mobile defense which could have caused the British army some difficulty was probably available to the German advisors if not the Turks themselves. However, the relative weakness of the Turks as well as their penchant for the static defense had caused General Otto Liman von Sanders, the German commander, to put a high proportion of his troops in defensive positions and hold out few reserves for counterattack. Under the circumstances of his own reduced capability for mobility, this was probably the best course of action and thus a truly mobile doctrine was precluded.

Comment: The British had at hand an appropriate, well-devised doctrine and an organization to implement it. The Turks, although probably aware of a mobile defense doctrine had none of the tools or conditions for implementing it and, in effect, were doomed from the start against Allenby's scheme.

Command, Control, and Communications for Mobility

British: A dynamic and flexible system was in effect with commanders at all levels operating well forward with main efforts, urging units forward, coordinating operations, securing support, modifying orders to suit circumstances, making personal reconnaissances, and exercising initiative. Allenby set the pace for this and was wide ranging in his command car. On one day, for example, he motored more than 200 miles over unsurfaced roads and tracks visiting commanders and advancing units and performing all the activities of a mobile commander enumerated above. Radio was used on the modern scale of the British army of that time which was relatively greater than the Turks. A sufficiency of horse-flesh, motorcycles, and automobiles together with possession of and operation over the best routes enabled rapid physical communication and liaison.

Turkish: By comparison the Turkish system was cumbersome and was further hampered by British air attacks on all major headquarters which coincided with the ground attack. This resulted

in completely stopping all communication between the Turkish Eighth Army and von Sanders' headquarters and greatly delaying that with the Seventh Army. As British cavalry got in their rear, Turkish units were cut off from physical communication and the process of disintegration was accelerated. Liman von Sanders himself was driven from his headquarters at Nazareth and almost captured by a brigade of the 5th Cavalry Division at 0430 on 20 September just 24 hours and over 60 miles from the infantry jump-off.

Comment: The British had a means of mobility and a system for its employment and, as important, a brain and nervous system to guide and drive it. The Turks had barely enough to escape with a fraction of their force.

Intelligence for Mobility

British: Having air superiority the British through air reconnaissance and photography were able to pinpoint all Turkish forces and to assess terrain and routes of communication. The local inhabitants, including the Arabs in the interior cooperating with Lawrence, were unfriendly to the Turks and provided information of all kinds to the British. Radio intercept and normal intelligence methods revealed further details of dispositions and terrain that would serve the exploitation of mobility. Just as Patton studied Froisart, chronicler of the Hundred Years War to learn of Norman fords passable to his tanks, Allenby read the Bible, Greek and Roman historians, crusader histories, and such secondary sources as Smith's Historical Geography of the Holy Land to learn of the roads, tracks, passes, and obstacles that would either enable the exercise of mobility or impair it. These rather unusual measures were necessary due to the poor maps available and the lack of geographical intelligence studies which are commonplace today.

Great use was made of deception indicating a build-up for an attack on the Jerusalem-Deraa axis in order to keep the bulk of the Turkish force in the hills to the east. This deception effort was reinforced by effective counterintelligence which prevented the Turks from penetrating the ruse. In addition, fighter sweeps kept German reconnaissance aircraft serving the Turks grounded.

Turkish: That the Turks were blinded to British preparations and moves is evidenced by a captured map which showed what the Turks believed to be British dispositions -- in the exact false detail that the British intended them to believe.

Comment: While mobility enabled the surprise incursion into the Turkish rear, intelligence and counterintelligence enabled the surprise attack which assured penetration and launched the mobile force towards the enemy rear.

Firepower as an Adjunct of Mobility

British: 35,000 infantrymen and 400 guns were opposed to 8,000 Turks and 120 guns to blast a hole in Turkish defense and launch 9,000 cavalry in exploitation. Without such an overwhelming superiority in firepower the breach which permitted the exploitation of the mobile capability could not have been made.

Turkish: The massing of sufficient firepower to stop the British advance and pursuit was never possible. The onslaught was so rapid and the pursuit so relentless that rear guards and delaying forces were either ridden down or ridden around and cut off. In but one case did the British cavalry suffer a repulse when the leading brigade of the 4th Cavalry Division was overconfident in attempting to dispose of a strong flank guard of the Turkish Fourth Army which was retreating up the Hejaz railway.

Turkish mobility was severely hampered by British air attacks, which struck columns on the move. In one case a column of 100 guns, 1,000 vehicles, and thousands of troops was hit in a defile which was blocked and the whole force captured by pursuing cavalry. Lawrence's Arabs served a similar purpose in cutting the Hejaz railway.

Comment: Where the axes of the mobile advance are defended and there is no flank around which to maneuver, firepower must be used to make a gap through which the mobile force can be launched. Interdiction of enemy routes may enable pursuing units to catch up to and destroy a retreating army.

Terrain and Mobility

British: The initial objectives of the mobile forces were terrain features, the capture of which would enhance the mobility of the whole force in reaching of final objectives of Damascus and Aleppo. These were the passes through the Mount Carmel ridge, rail junctions on the Haifa-Deraa lateral road, the strategic railroads and roads themselves, and Jordan River bridges. To reach these objectives, flat terrain of the coastal plain suitable for the rapid movement of mobile forces was chosen.

Turkish: By the loss of these good routes of communications the Turks were forced to use mule tracks in the hills for their retreat which so reduced their mobility that most were captured.

Comment: Terrain was exploited by the British in this case both to permit a rapid advance by friendly forces and force the enemy into terrain where his movement was slow.

Campaign in France and Flanders - 1940

"Thus the defeat of France started from a failure of military doctrine to keep pace with changing conditions. It was due, above all, to obsolete habits of thought and the perpetuation of the slow-motion methods of World War I."

Captain B.H. Liddell Hart in
his Forward to The Battle of
France, 1940 by Colonel A.
Goutard.

Situation

The principal features of the operations were as presented in HERO's study report: "Historical Trends Related to Weapon Lethality" (Annex Volume I, pp. 93-95.):

When Germany attacked, on May 10, 1940, France and Great Britain had on the ground 56 French and two British tank battalions, a total of 58, plus some British light cavalry tank battalions. German tank battalions totaled 35, organized in 10 panzer divisions, some of which were short their complements of tank units. French and British tanks available totaled about 2,700 while those in German units were 2,574, and another 800, mostly light, in reserve, a total of about 3,500. Further, the French and British tanks were, except in a few instances, qualitatively superior to the German.

The German attack was launched on May 10, 1940, by Army Group B (von Bock) in the north with two armies under his command, Army Group A (von Rundstedt) in the center with five armies, and Army Group C (von Leeb) in the south with two armies. Von Bock's mission was to penetrate Holland and Belgium north of Aachen, while that of von Leeb was to pin down the large French forces in

and behind the Maginot Line by threats and demonstrations. Von Rundstedt's was the principal mission, to break through to the channel and cut Allied forces north of the Somme from the main French armies to the south.

Opposed to the main German thrusts in the north and center were the Dutch and Belgian armies and French Army Group I (Billotte), composed of six armies and the British Expeditionary Force. The problem of command was complicated not only by the refusal of the neutrals to coordinate a defensive plan but also by the insistence of the British commander (Gort) that he was not subject to Billotte's orders but only to those of the French commander in chief. Facing von Bock were the BEF and the French Seventh Army (Giraud), the best trained and most fully equipped France had put in the field. Opposite von Rundstedt in the Ardennes was the French Ninth Army (Corap), with a large proportion of reserve divisions inadequately equipped, without antiaircraft and antitank weapons, and made up of elderly reservists inferior training, discipline, and morale. This distribution of forces reflected the Allied preoccupation with a Schlieffen maneuver and the conviction of the French high command that the Ardennes was impassable by armor.

Seven of the ten panzer divisions were assigned to Army Group A and three to Army Group B. Von Rundstedt organized an armored army under General Ewald von Kleist for the Ardennes penetration and von Kleist nominated Guderian's XIX Corps for the spearhead.

Von Kleist's attack was preceded by heavy dive-bomber assaults on known Belgian positions and on targets of opportunity, to some of which they were directed by ground commanders. A rifle battalion was air-landed in Storch liaison aircraft at Vitry, some 30 miles ahead and just over the Luxemburg-Belgian border. Guderian's spearhead pressed rapidly through the Ardennes brushing aside weak Belgian and French resistance.

The major obstacle to be surmounted was the Meuse river, whose bridges had been demolished. Engineer parties from the panzer divisions' organic engineer battalions rushed the river line in rubber assault boats closely followed by infantry. When these detachments had sufficiently expanded their bridgeheads, engineer bridge units laid ponton bridges over which the armor crossed.

By the end of six days Guderian's panzer corps had penetrated more than 100 miles and appeared to be gaining momentum west of the Meuse. Hitler was so upset by this audacious thrust with its two long flanks that, in Halder's words, he was "terribly nervous and frightened by his own success." His insistence on protection of the south flank led to commitment to that task of a number of infantry divisions which could more profitably have been used for exploitation and widening the salient.

On the Allied side, the British and French north of the Somme were overwhelmed by the converging attacks of Army Groups A and B. South of the Somme some piecemeal and loosely coordinated efforts were made by elements of France's four armored divisions to break into von Kleist's south flank. In these efforts the 1st Armored Division was destroyed and a fairly well-coordinated attack by the 4th Armored Division (de Gaulle) was easily beaten off. The other two French armored divisions, distributed among the infantry, made no impression on the German advance.

The net result of the German concept of armor organization and tactics and their aggressive and imaginative employment of this arm was an unprecedented victory in western Europe. Reaching the Channel in 15 days, Kleist's armored spearheads turned north, joined with elements of Army Group B and penned the Allied forces between them and the Channel. Eight days after resistance in the north had ceased the regrouped German armies struck southward across the Somme and within less than a week France capitulated.

Physical Mobility

German: Tanks had a speed of 25-30 mph with a fuel range of from 75 to 125 miles. Refueling was highly organized and maximum use was made of captured and civilian stocks of POL. Motorized unit trains and motorized re-supply columns were used extensively and effectively. The initial follow-up infantry divisions were motorized. The next wave of follow-up infantry divisions used to exploit the breakthrough made by the armor, although on foot with horse-drawn transport, were hard marching.

By the employment of attack aviation, which could fly quickly to the point of main effort from easily supplied bases far to the rear, as a substitute for masses of medium and heavy artillery,

which would have clogged roads and slowed overall mobility in keeping up with the advance, the Germans not only maintained their heavy firepower which was essential to a breakthrough but they did so without sacrificing mobility.

French: With the exception of the fast (29 mph) and long range (140 miles) SOUMA tank which comprised 15-20% of the total number, French tanks had about half the speed and range of the German tanks. French doctrine (see below) dictated a sacrifice in speed and range for firepower and protection. Thus all French tanks had 37mm guns or larger and included a large number of 47mm and 75mm guns. Roughly speaking, any French tank gun could penetrate the armor of any German tank while one-half (PzKwI&II) the German tanks were ineffective against the French, one-quarter (PzKwIII with a 37mm gun) were marginal against the lighter French tanks, and one-quarter (PzKwIV with a short 75mm gun) were effective against all but the heavy French tank. The short fuel range of French tanks dictated that, for highly mobile operations, refueling be organized down to the last detail. As the French did not contemplate this type of operation, this was not done. The most mobile portion of the French army, in terms of first class trained divisions with motorized transport, was drawn into Belgium and Flanders and cut off, thus nullifying its mobility through denial of logistic support, particularly POL. The remaining forces to the South, which had to be used to plug gaps and launch counterattacks against penetrations, generally were reserve formations, with older, less fit men, had less training, and lacked motor transport.

Comment: The Germans, in sacrificing overall armor protection and gun power for speed and range, still retained a sufficiency of these qualities to accomplish the combat mission once the speed and range brought them to contact. That is, their tanks had enough armor to protect against light weapons in any case and at least some of their tank guns could defeat the French tanks. By this wide margin of advantage in speed and range the Germans outstripped the French armor, successfully attacked unarmored units, and seized and consolidated objectives before French armor could come up and launch a successful counterattack. By the massing of their armor, the Germans not only got there "fustest" but they got there with the "mostest" as well.

The French dilemma is best summed up by two quotations from Goutard. "Lacking speed and wide radius of action, our tanks either arrived too late or not at all, or ran out of fuel in the middle of the battle and had to be destroyed by their crews" and

"Instead of countering maneuver by maneuver, we only attempted to contain, according to our outmoded notions, an enemy who was always one step ahead."

Mental Mobility

German: With mobile materiel and a mobile doctrine and organization for its employment, the Germans in training and from actual combat experience in Poland had developed the mental attributes which have come to be known as the mobile mind. These included such characteristics among leaders at all levels as drive and energy, flexibility, willingness to seize the initiative, rapid coup d'oeuil, and quick decision.

French: The French, thinking in terms of a powerful defense of strong fortifications and massed firepower were methodical in thought and staff functioning and ponderous in movement. With a continuous front holding off the attacker there was ample time to bring up quantities of artillery and its ammunition and move infantry reserves by normal methods and time tables. Planning must be complete in every detail to ensure success.

Comment: The French may not have been outfought in every instance but they were out-moved, out-maneuvered, out-concentrated, and out-thought in most every instance. Rapid mental processes maximized the physical capabilities of mobile materiel and exploited the possibilities of a mobile doctrine and organization.

Mobile Doctrine and Organization

German: As in 1914-18 the Germans thought in terms of offensive action to secure lebensraum. They had developed an infiltration technique in 1918 that was almost successful. Building on the success of this idea and attempting to overcome the deficiencies of the 1918 attack by exploiting the mobile firepower of the tank and airplane the Germans developed a doctrine which became known as blitzkrieg. Flexible, integrated, mobile combat teams of all arms were organized as such at each level. They were built around the tank which conferred protected firepower and speed and range in the advance which were so lacking in 1918. These combat teams would be organized into armored divisions, corps, and armies which, supported by the heavy mobile firepower of attack aviation, and working in conjunction on narrow frontages, would break through enemy defenses, cut off, surround, and capture enemy units, seize key objectives deep in enemy territory, and so disrupt the enemy

defensive organization that collapse of the front and defeat were inevitable. Tactics and organization for this doctrine down to the last detail to include mobile logistic support were worked out and implemented.

French: The French were blinded to the realities and potentialities of modern warfare with modern materiel by their general success in 1914-18 in absorbing and then stopping German offensives (and the comparable German success in absorbing and stopping Allied attacks). The French tended to overlook the possibilities of this type of offensive, with improved and more mobile equipment, for their own use and ignored the problems attendant in countering it when used against them. As a result, they tended to refine the doctrine, organization, and materiel which had been successful in defending against World War I attack methods and materiel. This called for strong defensive positions in depth, supported by quantities of artillery which meant a ponderous movement of guns and huge stocks of ammunition. It was assumed that movement of infantry divisions in reserve needed to be no more rapid than in World War I. Staff planning and functioning was slow, methodical, and complete and the decision making of generals was in keeping.

While the French had almost exactly the same number of tanks as the Germans and they were substantially superior in armor and armament, although not in speed and range, they had neither the doctrine nor organization for their appropriate employment against the Germans. Some 2,400 tanks were organized into 54 battalions. One-half of these, or 27 battalions, were organized as separate battalions and assigned to infantry divisions for close support of assaulting infantry. The remaining 27 battalions were belatedly organized into so-called armored divisions in early 1940 after the German success with this organization in Poland. These formations did not have a well thought out doctrine as did the Germans and in the short time between their organization and 10 May 1940 they had little time to train together. Even more important, they were not really armored divisions. The three armored divisions and the three cavalry light mechanized divisions had four tank battalions each while the fourth armored division, committed later from the interior, had three battalions of heavy tanks. But these formations were not combined arms teams in the divisional sense but were in reality only tank brigades. They had no mechanized, armored, or even motorized infantry; no self-propelled artillery or any artillery; no special engineers required for armored units; no special signal units; and worst of all no appropriate mobile logistic support, especially that needed for frequent and expeditious refueling to keep the short-range French tanks going. All the

support designed to maintain the mobility of the tank's armored firepower was lacking. Further, French armor was committed piecemeal with never more than one division committed at one time.

Comment: The Germans had a completely developed and appropriate doctrine and organization of armored and mobile combined arms teams supported with the heavy firepower of attack aviation which was rapidly concentrated against enemy weakness and once a breakthrough was achieved it was extended, sustained and exploited by the speed and range of combat units, their mobile logistic support, and mobile reserves.

The French, on the other hand, had a doctrine and organization of slow, ponderous, sure moves which, although they had the power when allowed to develop it with unimpeded and covered concentrations, could not cope with the swifter reacting, swifter moving German forces which were able to concentrate sufficient power at the decisive points always ahead of the French.

Command, Control, and Communications for Mobility

German: Armored units leaders habitually commanded from a forward position with - or just behind - the main effort or advance guard. For this purpose they were provided with specially and completely equipped command vehicles. These contained radio equipment by which subordinate, adjacent, higher, and supporting arms units, including aviation, could be contacted. These vehicles were tanks at the lower echelons of tank units and at other levels were half-tracks with comparable mobility. At the lowest tactical level, tanks had radios for communication between tanks by which their tactical efforts were coordinated. From top to bottom command and control was positive yet flexible through doctrine and redundancy of equipment. A wide latitude of initiative was allowed and encouraged through mission type orders.

French: Tanks could not intercommunicate by radio as their intended mode of employment was in close cooperation with infantry. Thus they lacked the speed of reaction and flexibility necessary in mobile operations. Operations were carefully pre-planned and controlled through objectives and phase lines to a meticulous degree of detail to ensure a uniform advance and constant artillery support. Commanders were allowed little or no leeway for flexibility or initiative. There was little dynamism in command; withdrawals were permitted and attacks called off for insufficient reasons. Through imperfect communications arrangements

at every level commanders lost contact with their units at critical junctures. Even Gamelin, the supreme commander, was virtually out of touch with Georges, the battle commander, who had little better contact with the French armies. (In other words, they were guilty of the same kind of communications failure which caused the Germans to lose the Battle of the Marne in 1914.) This whole system was hardly conducive to the conduct of modern mobile warfare not to mention the effective command of the imperfect resources possessed.

Intelligence for Mobility

German: German intelligence and reconnaissance determined that the Ardennes was passable and indicated just how it could be passed through and what arrangements would have to be made. Intelligence collection to support operations was well organized with full information on roads, bridges, POL stocks, terrain, etc. developed. This was kept current by aggressive battle reconnaissance by commanders, armored reconnaissance units of armored divisions, and light aircraft.

French: Lacking the doctrine and organization for mobile warfare, the French lacked the essential supporting intelligence organization and the reconnaissance means as well. This resulted in the French usually being in the dark as to current German positions and what information was available was hours, if not days, out of date.

Comment: To maintain the mobility that a force is capable of it must have intelligence of the factors that can inhibit its mobility -- terrain and the enemy. At every level it must have appropriate reconnaissance means to secure this intelligence. The Germans had this, the French lacked it.

Firepower as an Adjunct to Mobility

German: Firepower was concentrated at the decisive point to achieve the penetration and breakthrough. Thus attack aviation carrying bombs heavier than the projectiles of all but super-heavy and virtually immobile artillery were, through their mobility, concentrated over the decisive point from distant bases. This fire shocked, demoralized through its newness, and contributed to success at the Sedan crossing of the Meuse and at many other points where French resistance held up the advance.

The mobile and protected tank is itself concentrated firepower -- multiple machineguns and a cannon with a crew of two to five and occupying a much smaller piece of terrain than if unarmored -- which is multiplied in its effectiveness by its ability to close with the target and so render its fire more effective all the while being protected.

The German field artillery could throw only about 2/3 the weight of metal and explosives in one salvo as could the French, but much of it was more mobile, enabling battlefield concentration, and was employed more aggressively and liberally.

French: Firepower was employed under an entirely different concept -- to inhibit enemy mobility by barriers of fire rather than to ensure one's own mobility by breaking through the enemy's defended front. Because of imperfect command and communications arrangements artillery was employed timidly and inflexibly with the result that enemy mobility was not hampered appreciably. In a like manner, attack aviation could not be concentrated at decisive points to stop German mobility.

Comment: The Germans successfully used firepower to unleash a mobile capability and then keep it rolling so that French and British units could be outmaneuvered, cut off, and defeated. This was accomplished through mobility which permitted concentration and aggressiveness in employment. The French, on the other hand, while having another purpose in mind for its firepower, that of inhibiting enemy mobility, failed to achieve this purpose through doctrinal inadequacies, timidity, and lack of flexibility.

Terrain and Mobility

German: By an especially detailed reconnaissance, a perceptive estimate of possibilities, thoroughgoing preparations, and vigorous execution, the otherwise unfavorable terrain of the Ardennes was exploited to enhance mobility. Once the breakthrough at Sedan had been achieved the Panzer army of von Kleist struck west down the valley of the Somme. To the left flank and protecting it was the Somme River, the crossing sites of which could be easily guarded. Crossing of major watercourses was avoided. The advance was along the roads of the north bank of the Somme and on the upland roads of the watershed between the Somme valley and the streams running north to the Sambre and Schelt Rivers. Thus the going was not only good but there were no serious terrain obstacles in the way.

French: France's strongest natural frontier in the north-east -- terrain along the Rhine, Saar, and to the Belgium-Luxembourg border -- was further strengthened by construction of the Maginot Line. For various reasons, however, the weaker terrain along the Belgium border was not effectively fortified. Although the Maginot Line defenses were proven to be penetrable, this type defense along the Belgium border might have so inhibited the German mobility as to reduce the effectiveness of the blitzkrieg and give the slow reacting French time to counter. Such counter-attacks as the French were able to mount were often against strong terrain of the German's choosing which tended to nullify the French mobility.

Comment: If the capability for mobility is to be exploited fully, terrain for movement to contact, the battle itself, and exploitation should be selected accordingly.

Malaya and Burma - 1941-1942

Situation

On 8 December 1941 Japanese planes struck at British airfields in Malaya and Singapore followed by landings in northern Malaya and just across the border in southern Thailand. The objective was the capture of the Malay Peninsula and the strategic base complex at Singapore some 500 miles to the south. The Japanese invaded with about three divisions, four tank regiments, and relatively strong artillery support. All were combat veterans and trained in jungle warfare. The British, on the other hand, while slightly more numerous, were not jungle trained nor tropically acclimated and were underequipped due to the losses and demands of the European war.

The Japanese secured command of the air and sea early in the campaign which enabled them to interdict British supply routes, and to make amphibious landings in the rear of British units retreating down the coastal roads. Not only did the Japanese, with their superiority in tanks and motorized equipment, have greater mobility on the roads which were defended by the British but they also had superior mobility through the jungle. This enabled them to bypass defenses across the roads and to establish roadblocks in the rear of the British, which usually resulted in collapse of the defense through lack of supplies and reinforcements. The Strait of Johore separating Malaya from Singapore was reached by the end of January and exactly two months after the initial

landings the Japanese assaulted across the straits to take Singapore. The average daily rate of advance was thus a very respectable $8\frac{1}{2}$ miles.

With the campaign in Malaya going well, in mid-January the Japanese struck across the mountains of the southern Thai-Burma border against Moulmein. Two divisions of jungle trained veterans were employed and the weight of the air effort was shifted to support this new invasion. The British force was about one and one-half divisions, also poorly equipped and trained for the conditions encountered. Conditions, methods, and results were about the same as in Malaya. The British were driven out of Burma by mid-May. The Japanese covered over 800 miles in four months for an average daily rate of advance of about 7 miles.

Physical Mobility

Japanese: Several favorable characteristics were present. These were foot mobility appropriate to the jungle terrain, modern motor mobility including armor for use on roads, sea mobility enabling turning movements from the sea which placed the Japanese astride lines of communication, and air mobility which enabled interdiction of enemy lines of communication.

Japanese infantry possessed typical oriental hardness, honed keen by the Japanese discipline, plus Bushido (esprit de corps), rigorous training, combat experience in China, and specific jungle training to fit them for these campaigns. They were adept at moving through the jungle, and in the use of tracks and trails and expedient local means of transport for tactical logistic support. Thus their lightly encumbered infantrymen were able to bypass British defenses astride roads, strike through the jungle, and emerge miles in the defender's rear to establish a road-block across their LOC. This resulted in the unhinging of the British roadbound defense and a retreat followed closely down the main road by Japanese road-mobile forces.

The four tank regiments deployed by the Japanese in Malaya and their tanks in Burma enabled rapid movement on roads and in the occasional open country during the dry season. The few available British tanks and anti-tank guns were insufficient to cope with these superior forces. The Japanese also used appropriate quantities of motor transport, supplemented by captured and requisitioned vehicles. Thus support was kept up with the lead elements at all times.

Having command of the sea, and amphibious ships and craft as well as trained units, the Japanese resorted to coastal shore-to-shore landings on several occasions. In some cases local fishing boats were seized for this purpose. Thus the Japanese were able to use the sea as well as the jungle in mobile, offensive operations. British defenses along the coastal roads were bypassed, blocks set across the LOC, and the defender turned out of his position. The sea flanks were also used to keep logistic support up with the attack, without the resort to a long haul over the roads.

Japanese air superiority was used to interdict the British LOC, and to hamper their mobility - and thus indirectly enhance Japanese movement.

British: An almost complete antithesis obtained, with the British being distinctly inferior in off-the road mobility, inexorably losing road mobility through the attrition of air attack and roadblocks in the rear, and lacking the mobility afforded by the possession of air and sea superiority.

Comment: The Japanese appear to have had everything in their favor. The tenacious fights put up by British and Commonwealth troops, their sacrificed rear guards, and the difference in terrain between Southeast Asia and Europe, prevented the Japanese from achieving the 20 miles per day rate of advance of the Germans in their Blitzkriegs of 1939-1941.

Mental Mobility

Japanese: Trained and experienced in years of mobile warfare against the Chinese, Japanese leaders and troops were mobile minded. While perfectly willing to assault frontally where necessary the Japanese preferred and were mentally as well as physically capable of taking the longer way around to achieve quicker and less expensive results.

British: Defeats in Europe, physical debility due to lack of acclimatization, lack of confidence through lack of experience and appropriate training, and the defensive posture forced by Japanese superiority, all must have contributed to low morale and a certain mental stultification at all command levels, inhibiting daring mobility in the unfamiliar jungle to counter the Japanese mobility there.

Comment: The Japanese, through all the favorable elements contributing to their success and high morale, had achieved a moral as well as a physical ascendancy over the Allies at this stage of the war. It was only overcome through bitter experience, hard work, and heavy loss.

Doctrine and Organization for Mobility

Japanese: Through long years of mobile operations of combined arms and joint forces in the China Incident the Japanese had evolved a body of doctrine both for the combined arms of ground forces and for the integrated operations of army, navy, and air forces. This, and the supporting organizational details, hammered out and refined in years of active combat operations, were initially superior to the doctrine and organization of the relatively inexperienced Allies. This doctrine provided for mobile operations in primitive terrain including the jungle, amphibious operations supported by sea and air forces, and support of land and sea surface operations by air forces.

British: Rationalized doctrines and integrated organizations for modern mobile ground operations, particularly in primitive areas, amphibious operations, and direct air support of surface operations, were still in the formative stages. Organizational problems also plagued the British due to their shortages in modern weapons and equipment and the diverse elements of their forces -- British, Australian, Burmese, Indian, African.

Comment: Relative to the opposition, Japanese doctrine and organization was rationalized, optimized, and totally appropriate to the situation and conditions encountered. The British, on the other hand, were still in the developmental stages and lagging far behind. It was two more years before the British caught up, partly because of the psychological ascendancy achieved by the Japanese in these campaigns. The off-the-road mobility in primitive areas exhibited by the Japanese in these campaigns, by the North Korean and Chinese Communist Armies in Korea in 1950-1951, and by the North Vietnamese from 1948-1967, suggest that it may not derive just from necessity met by oriental physical hardiness but may be a unique, oriental doctrinal tendency. This hypothesis bears further investigation. On the other hand, Japanese influence and example may have something to do with the doctrines of these more recent oriental forces.

Command, Control, and Communications for Mobility

Japanese: Little is available on the detailed arrangements of Japanese command, control, and communications, but again from years of operational experience in China the system was shaken down, experienced, and effective. An important aspect was that their electronic communications equipment was suited for the tropic climate and the operators experienced in the peculiarities of radio communications in that environment.

British: The system was largely makeshift due to lack of operational experience, unfamiliarity of units to the area and the command, lack of appropriate doctrine, and insufficient effective communications.

Comment: The Japanese system was appropriate for mobile operations and complemented other favorable capabilities for mobility. The British deficiencies in this area compounded other shortcomings in the elements of mobility.

Intelligence for Mobility

Japanese: The Japanese were merely executing a well prepared plan which was part of their expansionist overall Great East Asia Co-Prosperity Sphere plan. Overseas Japanese, spies deployed for specific missions, and anti-British sympathizers acted as intelligence agents. The Japanese also had a fifth column, the cadre for which had been trained in Japan, which gathered strength during the invasion and which acted as guides and liaison with the local people. Among the intelligence they acquired was that relating to the mobility of both sides, such as the best trails through the jungle, or the best place to block British mobility. In the area of tactical intelligence, the Japanese penchant for infiltration often resulted in discovery of gaps and routes which released their off-the-road capability for mobility.

British: Not anticipating combat in the area at this early date, British intelligence preparations were less well developed and were makeshift. The British, being the colonial masters of the indigenous population, often found few local friends to give them information in contrast to the pre-planned networks of the Japanese.

Comment: The Japanese were executing a well conceived plan based on near complete intelligence as to, among other things,

terrain and routes of communication so essential for mobility. The British, in contrast, were virtually blind when away from the main roads shown on standard maps.

Firepower as an Adjunct to Mobility

Japanese: Superior firepower, more artillery, more tanks, air superiority, and naval gunfire enabled the Japanese to reduce British mobility by interdiction, pinning down their defensive forces while they were flanked, and neutralizing their mobile air and naval firepower. It also enabled the Japanese, when necessary, to make penetrations by direct assault and restore mobility as in the Strait of Johore crossings and assault of the island of Singapore.

British: Air and sea mobile firepower was lost early in each campaign to the detriment of relative mobility. British general deficiency in artillery and tank firepower caused a defensive and delaying posture with inevitable progressive deterioration.

Comment: It appears that once relative discrepancy in means becomes marked, deterioration of the weaker side progresses rapidly to disaster.

Terrain and Mobility

Japanese: The main advances were, of necessity, confined to main routes of communication but the Japanese were prepared to exploit unfavorable terrain -- the sea and jungle flanks of the main routes -- to keep the routes open. Thus, terrain which might be considered an obstacle to a European type army was not only not an obstacle, but was exploited as a usable route of access to the defenders' rear.

British: Denied the use of a sea flank by their loss of command of the sea, the British also denied themselves use of the jungle flank by lack of preparation to operate in this difficult terrain.

Comment: A force unable to operate effectively in every terrain that it may encounter may find that it has lost relative mobility to an opponent who is able to so operate.

Campaign in North Burma - 1945

Situation

As General Slim's Fourteenth Army approached Central Burma from the west it became apparent that the Japanese had concentrated their forces at Mandalay for its defense. General Slim first attacked across the Irrawaddy some 30 miles north of Mandalay with the 19th Indian Division of the IV Corps on 14 January, 1945, and slowly fought down the east bank of the river towards Mandalay. Meanwhile the XXXIII Corps prepared to force a crossing of the river a few miles south and west of Mandalay which it did on 12 February. This drew more and more of the Japanese forces into the fight while the balance of the IV Corps was secretly shifted over 100 miles further to the southwest where it crossed the Irrawaddy at Pagan without opposition on 13 February. The objective of the IV Corps was the strategic Meiktila-Thazi area with its rail and road junctions and airfields 100 miles south of Mandalay. This area was astride the Japanese main supply route, both rail and road, from Mandalay to the port of Rangoon.

On 21 February the 17th Indian Division, heavily reinforced with British armored units and in effect an armored division, struck from the Pagan bridgehead across the firm plains of Burma's dry zone towards Meiktila and against light resistance. Six days and 100 miles later Meiktila was reached on 27 February, and taken on 4 March. From 4 to 28 March the Japanese counter-attacked incessantly with units detached from the Mandalay front. The 17th Division was completely surrounded during a considerable part of the battle, but as it held the airfield reinforcements were thrown in. Meanwhile, the 7th Division was fighting its way overland to Meiktila from the bridgehead while the detachments from Japanese forces defending Mandalay so weakened the defense there that XXXIII Corps was also able to begin to push south towards Meiktila. The Japanese counterattacks against Meiktila failed and the Japanese position in Central Burma was so unhinged that units at Mandalay and Meiktila retreated to the east and then down the Sittang River valley to Rangoon. This bold British maneuver, accomplished by exploitation of the elements of mobility, turned the Japanese out of a strong position and brought the campaign in Burma to an early end.

Physical Mobility

British: The mobility potential of armor was again affirmed. The British tanks, although not the newer heavier models necessary for warfare in Europe in 1945, still had good speed and range and sufficient protection to be extremely effective against the Japanese in open warfare. Quantities of motor transport had also been moved across the mountains from Assam and these and other arms and service support were used to support the tanks logistically. Because quantities of transport aircraft were already available for the main logistic support of Fourteenth Army across the mountains, these were available for the reinforcement of what amounted to an airhead at Meiktila. The mobile, far ranging firepower of attack aviation was also available to interdict the Japanese rear, to deny mobility by day, and to supplement a paucity of heavy ground firepower.

Japanese: Tanks were few and inferior and motor transport was inadequate. Dependence for long range transportation was placed on river and rail while tactical transport was by foot and animal drawn vehicles. These means of mobility were severely restricted by Allied air superiority which enabled constant interdiction of routes by day. While Japanese foot mobility and use of animal drawn vehicles was developed to a high degree, especially at night, it was inadequate relative to the Allied mobility through use of tanks, trucks, and aircraft.

Comment: This was a classic maneuver of the type which turns the enemy defense and places a powerful force across his lines of communication through the exploitation of superior means of mobility.

Mental Mobility

British: After five and one-half years of war, three against the Japanese, the British were completely shaken down and battle wise. They knew the most economical way to deal with as stubborn a defender as the Japanese was to turn him out of prepared defenses by maneuver out of the mountains and jungles. With the means of mobility at hand they were mentally prepared to use it effectively.

Japanese: While certainly mobile minded in the attack, exploiting any means at their command to the utmost, the Japanese

were too rigid in defense, tending to defend longer than necessary and thus, when maneuver by the attacker was possible, allowing themselves to be outmaneuvered.

Comment: The British having greater overall strength and greater mobility had the initiative, knew it, and kept it. The Japanese with less strength, less mobility, and with less mental flexibility, were slower to react, slower to move, and were levered out of Burma.

Mobile Doctrine and Organization

British: Although the British did not have armored divisions in Burma, they had sufficient tanks and other mobile equipment to reinforce infantry units and to create what were in effect armored formations of all arms, and employ them in this role when terrain and the mission permitted and required. Equally important, the British through five and one-half years of trial and error and stern instruction at the hands of the Germans, had developed a doctrine and practice of modern mobile warfare.

Japanese: Although possessing tanks and motor transport, the Japanese did not have the strategic and tactical problems which faced the Germans, nor the resources, and so did not develop a doctrine and organization for modern mobile warfare. They did have a mobile and maneuvering doctrine appropriate to their means but this was inadequate against the greater mobility and combat power available to the British.

Comment: While the British clearly held the advantage in the physical means of mobility they had the mental mobility and the doctrinal and organizational concepts by which the physical means were exploited to the maximum. They demonstrated their mental flexibility by, at the appropriate time, shifting from a mountain and jungle type war with restricted mobility to a highly mobile operation of armored forces on ideal terrain. The Japanese, in spite of their tenacious fighting abilities, were clearly out-classed.

Command, Control, and Communications for Mobility

British: Supported by the combined scientific and industrial capacities of the Allies, the British had ample means of communications, electronic and physical, to command and coordinate modern forces in mobile warfare. Support, whether by artillery, air,

supplies, or reinforcements, could be called up promptly by radio. Commanders and staffs visited units and made personal reconnaissances by light aircraft.

Japanese: Although possessing many of the attributes of a modern force, the Japanese did not have the scale of communications equipment to make it fully effective. Further, use of the air during this period was virtually denied them. The whole philosophy of command and responsibility of this oriental, feudal, semi-modern army was alien to the demands of mobile warfare against an alert, aggressive modern army, even though it had been more than equal to the task three years earlier against a relatively unprepared opponent.

Comment: Appropriate command, control and communications are essential, as are the other defined elements of mobility, if the potential of physical mobility is to be realized.

Intelligence for Mobility

British: The peoples of Burma had turned against the Japanese by this stage of the war and were providing the Allies with a useful network of intelligence agents behind Japanese lines. With command of the air the British had complete visual and photographic reconnaissance. All other modern intelligence means were at the disposal of the British. This system revealed the Japanese concentration at Mandalay and the weakness of Meiktila. Good counterintelligence concealed the flanking move of IV Corps prior to its river crossing. Intelligence files and reconnaissance provided and confirmed terrain information essential to the mobile maneuver.

Japanese: Denied a similar intelligence capability the Japanese were blind to the British moves until the blow struck.

Comment: Mobile means may not find a use if intelligence cannot assure good terrain, reveal a suitable objective, and make surprise possible by concealing the build-up.

Firepower as an Adjunct to Mobility

British: There appears to be no case in this campaign where firepower enhanced mobility by enabling a penetration or reducing a defense which was holding up a rapid advance. The capture

of Mandalay, however, just like the defense of Meiktila, was facilitated by superior British firepower, permitting British tactical mobility, and hindering that of the Japanese.

Japanese: In the negative sense, British firepower in the form of attack aviation as well as ground weapons, greatly inhibited Japanese mobility by attacking day movement and thus restricting movement to the hours of darkness.

Comment: Ability to inhibit enemy mobility could give a mobility advantage to one side where the other elements of mobility are nearly equal.

Terrain and Mobility

British: An appropriate objective in terms of terrain was selected: a communications center, the possession of which would inhibit enemy mobility and enhance one's own. By seizure of the road and rail center the Japanese were forced to use secondary roads to the east for a retreat and left the main road and railroad to British use. By seizure of the airfield, rapid reinforcement through the mobility of air transport was facilitated. The hard uplands of Burma's dry zone before the monsoon rains permitted armor cross country mobility and wheeled vehicles the use of unsurfaced roads.

Japanese: Conversely, the Japanese were forced off the main routes and into the hills which slowed their rate of movement still more. This resulted in the near disintegration of the Japanese armies in Burma. After Meiktila, while there were numerous hard fought rear guard and small unit actions, there was no serious contest of Allied advance.

Comment: Terrain must be viewed and used either to enhance one's own mobility or inhibit that of the enemy. In this case the British saw this perfectly. The Japanese thought that they had the main route south blocked at Mandalay and thus seriously misjudged their enemy's capability for mobility which could result in a strategic turning movement.

TRANSFER OF MODERN MOBILITY DATA TO HISTORICAL EXAMPLES

The Issues and Problems of Data Transfer

The laboratory of the military man has traditionally been war itself; from review and analysis of the records of past combat operations the perceptive soldier has learned lessons and obtained wisdom which have been useful in subsequent combat operations. This is unquestionably still true, at least insofar as basic strategy, fundamental operational principles, and the philosophy of combat are concerned. But rapid changes in technology have tended to make technical details of examples of past warfare relatively inapplicable to modern combat. This, of course, is a primary reason for the modern development of wargames and increasing reliance upon their results.

Yet the most ardent wargamer, even if he believes his specialty is reasonably precise and accurate, must admit that his models can never fully reflect the variety and scope of actual operations, and the interplay of the almost infinite number of individual human actions and reactions that contribute to the outcome of an actual battle.

If, however, it were possible to take actual combat experiences of the past to postulate a modern combat situation, and then--through wargaming or other analysis--estimate the manner in which the introduction of modern weapons or equipment might affect the outcome, the wargames would be enriched, while the actual results of the past engagement would provide a yardstick of reality against which to measure not only the specific analysis of this restructured situation, but other similar wargame results as well.

To make such a data transfer realistically in terms of modern combat, however, is easier said than done. Modern means of tactical mobility cannot be realistically or effectively introduced into situations in which the prior operations were based upon entirely different means and standards of mobility. Nor can modern means of mobility be applied unless modern weapons and equipment are also postulated, a requirement which would eliminate

the usefulness of transfers to wars and times in which modern technology would be completely foreign.

On a basis of the survey of mobility in military history, presented earlier in this study, it was arbitrarily decided that if there is any validity and usefulness to the transfer of modern mobility data to historical example, this would probably not be useful for examples prior to World War I. There is, in fact, considerable doubt if the results would be sufficiently reliable for any period before World War II. In the light of the purposes of this study, therefore, it was decided to investigate the manner in which such a data transfer could be applied to a major engagement of World War II. For several reasons, the German Ardennes offensive of December 1944 was selected, and three aspects of that operation were examined to see what might have been the results if modern mobility means were available to both sides.

Transfer of Modern Mobility Data to the Ardennes Campaign December 1946

Background

The Ardennes campaign was initiated by the Germans as a last desperate gamble to buy time on the Western Front. In this effort they used some 30 divisions, of which 7 were Panzer, 11 infantry, 2 parachute, and the remainder Volksgrenadier.

The broad German plan was to strike toward the Meuse and to Brussels and Antwerp, with the Sixth SS Panzer Army on the north driving through to Liege, the Fifth Panzer Army in the center making a secondary effort in a drive to the Meuse near Namur, and the Seventh Army on the south flank executing a diversionary attack toward Luxembourg to occupy the US Third Army.

For success the Germans required three basic elements. First and most essential was surprise; second was speed of execution and third--a concomitant to the second--was mobility. As General Model, commander in chief Army Group B, stated to his staff on December 6: "Quick exploitation of the success of the first day of the attack is decisive. The first objective is to achieve liberty of movement for the mobile units."

In essence, the Allies had the basic requirements for mobility. Sufficient transport and gasoline were on hand to move almost

unlimited numbers of troops and supplies by road or air under emergency conditions.

In contrast, the Germans were sorely deficient in motor transport by as much as 50% in the majority of their infantry divisions. The Panzer divisions were motorized or mechanized, the infantry and parachute divisions and the supporting logistic and artillery systems were to a large extent or wholly horse-drawn. Much of the existing motor equipment was in poor condition and spare parts were lacking, a vital necessity in extremes of weather and terrain. There was no air transport capability, after an initial drop of some 800 paratrooper-saboteurs.

The following pages will consider how modern mobility capabilities might have affected actions by German forces in the Ardennes, with particular attention to (1) the engagement at St. Vith, (2) the offensive actions of Kampfgruppe Pieper of the 1st SS Panzer Division, and (3) the engagement at Bastogne.

The St. Vith Engagement

General. St. Vith lay directly in the path of the Fifth Panzer Army in its move toward Namur. As a communications center, St. Vith was the focal point of five main highways and three rail lines, and by virtue of its particular location, if held by the Americans, would block not only the Fifth Panzer Army, but also all the support forces and supply trains endeavoring to feed the advance of the Sixth Panzer Army on the north.

The rugged hilly terrain of the Ardennes, heavily forested, permitted very limited cross-country movement. Frequent streams and numerous saddles added to the difficulty which channeled all vehicular traffic along the few narrow tortuous roads which served the area. As a key road junction, the capture of St. Vith would permit rapid deployment of German armor debouching from the restricted routes of the Schnee Eifel, permitting the armor to fan out in the American rear areas. Thus it was a key to the success of the German operation, which required that German spearheads be driven deep into American rear installations with speed, paralyzing American ability to react and fight back.

General Manteuffel in his analysis of the German counter-offensive stated that "for the attack to be successful at least three things had to happen: (a) The German attack had to be a surprise; (b) The weather had to be such as to prevent air strikes

on the German columns coming through the Ardennes; (c) The progress of the German main effort coming through and beyond St. Vith must be rapid and not delayed."

The first two of these requirements were met. The last was not, due to the defense of St. Vith by the 7th Armored Division. The German timetable called for the capture of St. Vith by 1800 on December 17, 1944. They finally succeeded in controlling the area around St. Vith on December 23, 1944. Because of this six-day delay General Manteuffel on the evening of December 24 recommended halting the entire offensive and retiring behind the West Wall.

The basic cause of this failure was the German's failure to move to St. Vith with sufficient speed.

The First US Army Report of Operations states:

The elimination of the St. Vith salient was of prime importance to the German C in C West. Because of the delay imposed here, the offensive was already three days behind schedule. In retrospect it can be said almost from the second day of the offensive, von Rundstedt's plan began to go wrong. . . .

The salient of St. Vith not only threatened the whole of the Fifth Pz Army's northern flank, but continued to prevent the movements of the Sixth Pz Army. This afforded the First U.S. Army sufficient time to bring up reinforcements to a new defensive line. . . .

The Preliminaries. The fate of St. Vith--and the outcome of the battle--hung upon whether the 7th Armored Division could arrive in time and with adequate force to occupy and defend it, or whether the German LXVII Corps could take the vital road junction.

On December 17 St. Vith was undefended and open to the Germans until elements of CCB 7th Armored Division began to arrive and go into position shortly after dark. The Germans explain their failure to arrive earlier on the fact that their forward movement was severely hampered by ice and snow on the narrow roads of the Schnee Eifel. On the other hand, the movement of the 7th Armored Division was seriously hampered by masses of vehicles of all types, including heavy artillery, fleeing the Germans in panic, and jamming the roads and towns through which the 7th Armored Division had to move to reach St. Vith. General Robert W. Hasbrouck, CG, 7th Armored Division, took five hours in his jeep getting from Willsam

to St. Vith, a distance of five kilometers. Only ruthless action by the 7th Armored Division enabled it to get through.

The Americans arrived at St. Vith just as the first German spearheads probed, to begin feeble, uncoordinated attacks. The halting of these spearheads jammed German columns to the rear bumper-to-bumper for miles. By the time it was realized that armor would be required to take St. Vith, the existing roads were already blocked by the horse-drawn trains and artillery units of the two Volksgrenadier divisions and LXVII Corps. The narrow roads and heavy forests permitted no double-banking. As a consequence, it took the Fuehrer Begleit Brigade--with over 100 tanks and assault guns vitally needed in the attacks on St. Vith--three days to arrive on the scene.

Assumption of Modern Mobility Capability. If we assume current means of military mobility for both sides, it is almost certain that, all other conditions of weather and terrain being the same, victory at St. Vith would go to the Germans.

The crux of the entire action with current mobility capabilities lies in the fact that the Germans had achieved total surprise, not only by the offensive, but in its weight and ferocity as well. "Just a local diversion" was the initial reaction of one intelligence officer. It was a good 24 hours before the US VII Corps Commander realized the full extent and power of the German offensive.

Thus, if the Germans were able to disguise the massing and whereabouts of some 20-odd divisions, given new methods of transportation such as troop- and cargo-carrying helicopters, these too could and would have been adequately hidden, and could have been employed to enhance surprise. Current means of mobility would of course have speeded up Allied reaction time as well. However, they had been caught off guard. The Germans had the initiative and knew the key communications centers and potential bottlenecks which must be seized early to assure success.

St. Vith was such a key area. Its early seizure was a prerequisite to the success of the German offensive and so recognized by them. Therefore, the seizure of St. Vith by a helicopter air-borne operation was made to order for helicopter assault.

Current US Tables of Organization for an infantry division show approximately 50 helicopters; 25 HULB or HULD in the air mobile company, 12 of the same type in the cavalry reconnaissance

company, and 12 more in the support company. A US Corps Headquarters generally is supported by an aviation group, one of whose battalions is a mixed helicopter battalion comprising one company of CH47s (Chinook) and three companies of HULDs. A US field army normally has one or two aviation groups with an attached CH54 flying crane company.

Capabilities of these helicopters are:

HULB or D--crew plus 10 combat-loaded infantrymen, or
3,000 lbs.

CH47--crew plus 30 combat-loaded infantrymen, or 16,000 lbs.

CH54--20,000 lbs.

Assuming German assignment of helicopters to division, corps, and army as essentially similar to that of the US Army, but taking into consideration their overall scarcity of equipment in 1944, the two Volksgrenadier divisions of the LXVI Corps might have had some 50 helicopters (HULBs) available, or 50% of their TO&E. The LXVI Corps would probably have had an aviation group of 75% of strength, or approximately 12 CH47s and 50 HULDs.

St. Vith lies approximately ten miles due west of the German lines of departure as they existed on December 16. It would have been a comparatively simple operation to pool the helicopters of the two Volksgrenadier divisions reinforced by the support of the helicopter battalion from corps, giving the Germans a total lift of some 112 helicopters. A reinforced battalion of infantry (900 personnel) would require the lift of about three companies of helicopters; the 75 HULs to transport personnel and the Chinooks to bring in heavy equipment and accompanying personnel.

Sufficient airlift was thus available to air land two reinforced infantry battalions on the high ridge north and west of St. Vith and on the high ground to the south and west with the mission of holding the high ground and blocking the access routes to St. Vith coming in from the north, northwest, south, and southwest.

Two lifts or two round trips would be required to land the major elements of two infantry battalions with a third round trip required for the CH47s for additional loads of ammunition, mines, demolitions, barbed wire, flares, and the like.

Assuming the airlifted assault infantry companies married up with the helicopters some 10 miles to the rear of the front lines, a distance of 20 miles had to be traversed at an average speed of

120mph. Thus 10 minutes after airlift, starting at H-hour (5:30 AM) elements of two infantry battalions would be landing to the west of St. Vith. Allowing 10 minutes to unload, 10 more minutes for the flight back to the takeoff point, 20 minutes to reload and 10 more minutes for the flight to St. Vith, by H-hour plus 50 minutes, or at 6:20 AM, both battalions could have been on position ready to fight.

The weather on the 16th was cloudy and remained overcast through December 22, so poor as to prevent high performance aircraft operations, but well within the capabilities of helicopters. In essence German helicopter operations could have proceeded uninterrupted by hostile aircraft for the first six days of the offensive.

Turning to US actions, it was not until 5:30 PM on December 16 that the 7th Armored Division received its warning order to prepare to move to assist the 106th Infantry Division in the St. Vith area. There were other units closer to St. Vith, but these divisions were committed to an early offensive against the Roer River dam. This plan was not cancelled until late on December 18 when the full weight of the German offensive was finally realized. Thus it was a full 12 hours after the German attack began that a US unit was alerted to move to the defense of this important area.

If we assume that the warning order and movement order for an heliborne assault force to move to St. Vith were simultaneous, it would still take approximately two hours for the assault troops and helicopters to get together, agree on routes and landing zones, etc. Hence at the very earliest, US troops could have begun their landings in the vicinity of St. Vith some 14 to 15 hours after the first Germans had landed.

It must be borne in mind that it was already dark (5:30 PM) when the warning order was received. No opportunity existed for daylight reconnaissance on the part of the crews making the flight or for the troops who were to attack and occupy the ground. The earliest possible takeoff time was about 7:30 PM on a dark low overcast night. As the extent of the emergency was still unrealized, it is entirely possible that such an airborne operation would not have been considered, particularly so as the 7th Armored Division was due to arrive in the St. Vith area early on the morning of December 17. Once it was realized that the clogged roads in the rear would preclude the 7th Armored from arriving until late afternoon of the 17th, such an operation might well have been mounted. By then it would have been far too late. Within a few hours of their initial landings, the Germans would have established

a formidable defensive blocking force, a force certainly capable of holding the approaches to St. Vith until their main forces arrived, probably by dark of the 17th, at the latest.

With St. Vith secure and the main German forces free to move rapidly into the American rear, time would not have been bought for the American forces to rally and for reinforcements to flow into and hold Bastogne. Major elements of the Fifth Panzer Army would have been in Bastogne on the morning of the 18th when it was undefended. (If indeed, they had not been helicoptered in late on the 16th or early on the 17th.) The net result would have been the success of the German timetable and a severe disruption to Allied plans, a disruption that might set back the Allied victory by many months. The Germans unquestionably would have reached the Meuse River in strength, probably forcing the Allies into a major withdrawal behind this river barrier.

In this particular instance, due to the surprise attained, and the capability of the helicopter to operate in extremes of weather, a convincing case can be established that the use of modern heli-borne forces by the Germans to seize St. Vith would probably have gained them a major victory.

Task Force Pieper

General. Turning now to the Sixth Panzer Army on the north and more specifically to the activities of the 1st Panzer Division, a trace of the activities of a Task Force (Kampfgruppe Pieper) of this division from December 16 through December 22 also lends itself to a study of what might have happened had current type helicopters been available.

The Situation. The Sixth Panzer Army was assigned the north flank and the main effort of the German offensive, with the mission of crossing the Meuse River on both sides of Liege, wheeling north and seizing Antwerp. The Fifth Panzer Army was to protect the south flank of the Sixth as it made its turn north. The timetable for the attack of the Sixth Panzer Army was: one day for penetration and breakout; one day for the armor to cross the Hohes Venn; to reach the Meuse by the third day and secure crossings over the Meuse by the fourth.

The Sixth Panzer Army attacked on December 16, two corps abreast, the LXVII Corps on the north composed of two infantry

divisions, the I SS Panzer Corps on the south attacking initially with two Volksgrenadier divisions and one parachute division. The II SS Panzer Corps was in Sixth Army reserve. The concept was to hit with the infantry divisions in the van, break the crust of the American opposition, and then pour the armor through and race for the Meuse.

The attack of the LXVII Corps through heavily forested areas with few roads ran into the US 99th Infantry Division, which was later reinforced by the US 2nd Infantry Division. The attack made slow progress, and rather than wait for the infantry to break through, the 12th SS Panzer Division was committed to create its own breakthrough. After three days of vicious fighting, the 2nd and 99th Divisions held along the Elsenborn Ridge.

In the south, the area known as the Lorscheim Gap was loosely defended by the 14th Armored Cavalry Group. This organization was hit by one infantry and one parachute division. After some hours of confused fighting, tanks of the 1st SS Panzer Division reinforced the German infantry. A clean breakthrough was effected for the 1st SS Panzer Division to exploit in the early hours of December 17.

The road net in this area was extremely limited and required the 1st SS Panzer Division to divide its forces into four columns. The first column to move out was Task Force Pieper, a strong armored formation consisting of a tank regiment, a motorized armored infantry battalion, a battalion of self-propelled artillery, a mobile company of engineers, and one company of attached Tiger tanks.

The mission of Task Force Pieper was to seize Meuse River crossings at Huy and drive west without regard to flanks, bypassing opposition in order to maintain momentum and confuse and disrupt American reaction as armor was reported deeper and deeper in their rear areas. The balance of the 1st SS Panzer Division was to follow hard on Pieper and keep his line of communications open until the follow-on infantry divisions could take over. Meanwhile the 12th SS Panzer Division was to move on a parallel course protecting Pieper's north flank.

The Operation. Task Force Pieper started its exploitation phase at 4:00 AM December 17 at the town of Bullingen, where a small cache of gasoline was captured and put to use in German tanks.

After refueling Pieper continued to the town of Stavelot defended by one squad of engineers. At dusk the lead German tank hit a mine as it approached the bridge over the Salm River; the German

column halted for the night, 42 miles from the Meuse. At 8:00 AM the next morning, December 18, the Germans made a dash and captured the bridge intact. Pieper then turned north toward Spa where it was known that there were large First Army dumps of gasoline and other supplies. Pieper was halted again by a handful of Americans who poured 124,000 gallons of gasoline along a narrow cut on the road and then ignited it.

Pieper turned back and headed for Trois Ponts, a small but key town where the Salm and Ambleve Rivers joined. Once across the Salm River, the country was open with an excellent road net. From here Pieper had a straight and short shot at the Meuse.

Trois Ponts was defended by 140 men of the 51st Engineer Company, who had been operating a saw mill until a few hours before. This group had one antitank gun (a 57mm. gun from the 526th Armored Infantry Battalion) and a few machineguns. As the vanguard of Pieper's column hove into view, some 20 tanks plus infantry, the 57mm. opened fire, halting the lead German tank. The shot gave warning to the men on the bridge, who promptly blew it.

As Pieper stated later, "If we would have captured the bridge intact, it would have been a simple matter to drive through to the Meuse early that day."

Pieper then moved north looking for crossings over the Ambleve River. A bridge was found, although the route to the crossing was over a narrow and tortuous back road.

The column crossed the Ambleve River at the village of La Gleize, and headed toward Werblimont. Again a squad of engineers blew a bridge over the Lienne Creek and Pieper was once more frustrated. Other bridges were discovered, but the weight of the Tiger and Panther tanks were far too much for the flimsy structures found. Pieper retraced his steps to La Gleize and, trapped in the narrow Ambleve Valley, headed for Stoumont.

A number of events now occurred that sealed not only Pieper's doom, but the success of the Sixth Panzer Army's part in the offensive.

First of all, Pieper ran out of gas completely. He couldn't even work his radios as there was not even enough gas to run the motors of his command vehicles.

Second, his forced meanderings on back roads had lost valuable hours and given the Americans time to react and move forces to counterattack.

Third, the supporting columns of the 1st SS Panzer Division and in particular the strong 4th column had been held up for over 24 hours by a series of hasty and random minefields, thus creating a large gap between Pieper and follow-on German troops.

Fourth, the 12th SS Panzer Division, supposed to parallel Pieper's advance and protect his north flank, had spent three days vainly endeavoring to crack through the Elsenborn Ridge positions. On the evening of the 18th, the 12th SS broke off this action to start moving to the south. Thus the north flank was exposed. This was quickly exploited by a counterattack by the US 30th Infantry Division.

Finally, expecting other units to follow him, Pieper had left only a small force to defend Stavelot to his rear. The 30th Infantry Division promptly routed this force, blew the bridge at Stavelot and dug in to prevent any further German advance west by the I SS Panzer Corps. Cut off and out of gas, Pieper now abandoned his vehicles, and with 800 men made his way back on foot to the German lines.

The conceptual essence of Pieper's operation was speed. Speed was denied by the actions of a handful of Americans imposing delays, mainly by blowing bridges at the last second. If only one or two of these bridges had been captured intact, Pieper would have been on the Meuse River on the third day, according to schedule.

It is difficult to estimate what might have happened if Pieper had succeeded. The difficulties of the Americans in reacting would have been compounded, and a general withdrawal over the Meuse might well have been required. It is conceivable that if Pieper had moved rapidly across the Salm at Trois Ponts, the German High Command would have quickly reinforced success and thrown not only the 12th SS Panzer Division, but the II SS Panzer Corps as well, in behind Pieper and fully exploited the operation.

As it was, Pieper's failure gave the Americans the essential time to assemble reserves, set up blocking positions, and then move rapidly to counterattack. Lesser factors also contributed to Pieper's defeat. First was the resourcefulness and bravery of a few groups of American soldiers in improvising hasty road blocks--minefields, demolitions, and in one spectacular instance, flaming 124,000 gallons of gasoline. Second was the failure of the follow-on units to keep the gap closed behind Pieper. Third was his inability to get gasoline. Fourth was the lack of bridging equipment or adequate engineer support in Pieper's task force.

Assumption of Modern Mobility Capability. If we assume that the divisions, corps, and army making up the Sixth Panzer Army had a normal US complement of modern helicopters, the assault lift would be as follows:

For the two armored divisions in the I SS Panzer Corps--
400 troops or 34 tons of materiel;

For the three infantry divisions in I SS Panzer Corps--
1,500 troops or 81 tons;

At I Corps--1,200 troops or 140 tons;

For the two infantry divisions of LXVII Corps--1,000 troops
or 16 tons;

At LXVII Corps--1,200 troops or 140 tons;

At Sixth Panzer's Army--750 troops and 90 tons or zero
troops and 175 tons.

Thus I SS Panzer Corps alone would have had enough lift for some 3,000 fully equipped troops and, with support from army, an ability to deliver 175 tons of equipment to accompany the troops.

As speed was the essence of the German ploy, a map study would have indicated to the German planners those key areas that had to be taken and taken early for the attack to succeed.

Specifically along the routes selected for the I SS Panzer Corps:

1. The town of Butgenbach and the northern approaches thereto;
2. The town of Malmedy and the northern approaches thereto--
i.e., the Malmedy-St. Vith highway;
3. The Stavelot bridge and the approaches from the north and
west;
4. The bridge at Trois Ponts;
5. A blocking position at Stoumont;
6. The First Army gasoline dump at Spa.

For the Northern Corps the key areas would have been: Hofen, Eupen, Verviers.

Since the German offensive achieved complete surprise, the areas enumerated above in both corps zones were essentially undefended on D-Day. A total of five infantry companies reinforced by heavy weapons--i.e., mortar, machinegun, and antitank sections (approximately 200 men) would have sufficed to take and hold the bridges and establish the necessary blocking positions. For the dump at Spa two reinforced rifle companies could have been assigned.

If the helicopter assault moved out at H-hour, troops would have been on their targets within 30 minutes, with success guaranteed as the few American troops present were rear area troops all of whom would have been killed or captured in bed. With these areas in German hands, Allied reaction might have been even slower than it was, due to the capture of individuals who might have given the alarm. In any event, the way would have been open for Pieper to race to the Meuse. While it is true that his follow-on troops would probably still have been delayed by hastily strewn minefields, the German blocking forces on the north flank would have been in position, and should have been able to prevent American interference until the follow-up echelons closed the gap. Furthermore, Pieper could have easily been resupplied with fuel by helicopter, even if the dumps at Spa were for some reason not captured. If these dumps were captured and held by the Germans, enough gas would have been on hand to supply the entire offensive. Or, if the dump were destroyed by the Germans, the US First Army would have suffered a severe gasoline shortage.

Bastogne

Situation. As the crow flies, the town of Bastogne, Belgium, lies some 25 miles due west of the front lines as they existed on December 16, 1944. A small town of 3,000 population, it was nevertheless the most important road and rail center in the Ardennes.

Bastogne lay on the southern flank of the Fifth Panzer Army in the area of responsibility assigned to the LXIII Panzer Corps composed of the 2nd Panzer Division, the 130th Panzer Lehr Division, and the 26th Volksgrenadier Division.

The Germans recognized initially the importance of Bastogne and made plans to seize it, if possible by a coup de main of the two Panzer divisions assigned to LXVII Corps. However, if there

were any possibility of the Panzer divisions being delayed in their race for the Meuse by having to fight for Bastogne, they were to bypass the town and press on toward the Meuse River crossings. The 26th Volksgrenadiers, in the event the Panzer divisions were unsuccessful, was to assume responsibility for the seizure of Bastogne. General von Luttwitz, commanding general of LXVII Corps, stated that Bastogne had to be taken at all events. "Otherwise it will remain an abscess on our lines of communication."

Operations. When the German attack began on December 16, Bastogne was undefended and unoccupied by American troops. As the attack developed and it began to dawn upon the Americans that this was a full-scale major offensive, General Troy Middleton, commander of the US VIII Corps, recognized the significance of Bastogne, and decided to defend the town, but was not given permission to do so until December 19. Meanwhile, as units were hastily assembled and ordered forward to slow down and halt the German drive, two--the 101st Airborne Division and CCB of the 10th Armored Division--were directed toward the Bastogne area as a good delaying position. A series of low-lying hills surrounding the town gave good fields of fire and dominated the road net emanating from the town. When the decision was reached to defend Bastogne, the 101st Airborne Division, with CCB of the 10th Armored Division attached, was assigned the responsibility.

By December 18, the LXVII Corps had punched through the 28th Infantry Division and its divisions were rapidly moving towards Bastogne. Simultaneously, troops of CCB 10th Armored and the 101st Airborne Division began to roll into Bastogne late on the evening of December 18. As CCB was the first to arrive, it was given the initial defensive assignment to move out in three task forces and block the approaches from the northeast and northwest. These blocking positions were to be held at all costs.

These three task forces collided with elements of all three German divisions of the LXVII Corps early on the 19th. The entire day was spent by the Germans in eliminating this opposition; a most costly delay, as it enabled the 101st Division to outpost and organize the defense of Bastogne.

On December 20 the LXVII Corps attacked, three divisions abreast, with the 26th Volksgrenadier Division making the main effort in the center, to take Bastogne. The two Panzer divisions were to bypass the town and push on to the Meuse.

Both armored divisions were successful in breaking through the outlying defenses, although at some cost in time, particularly in the south. The 2nd Panzer Division on the north almost reached the Meuse before it was halted. Meanwhile, Bastogne was surrounded, forcing the Germans into a major effort in men, materiel, and time to try and take it, in order to establish communications with the Panzer divisions. In the end they were unsuccessful.

General von Luttwitz stated later that if Bastogne could have been seized on December 18, both of his Panzer divisions would have reached the Meuse on schedule.

The basic point about the defense of Bastogne, as with St. Vith, was the actual physical occupation by US troops. The Germans wanted both key centers, if possible without a fight. They failed in both instances. These two setbacks threw the Germans off schedule by just enough time to enable the US troops to rally, regroup, and attack. Without these defensive operations, the Germans would have met their time schedule.

Assumption of Modern Mobility Capability. If both German and US forces are given current mobility capability, particularly in helicopters, what might have been the impact at Bastogne?

Assuming full US TO&E, LXVII Corps would have had available as helicopter lift, approximately 77 HULB and HULD helicopters organic to its three divisions, and 16 CH47s and 75 HULDs in the aviation battalion at Corps. By pooling all helicopters under centralized control an initial lift for approximately 1,700 personnel or two reinforced infantry battalions would be available.

Hence the Germans would have had the capability of outposting the hills of Bastogne on December 16 by 6:00 AM, or H-hour plus 30 minutes, with two infantry battalions. Allowing a round trip flight time of 40 minutes, a reloading time of 30 minutes, and an unloading time of 10 minutes, by H plus 2 hours 20 or 7:20 AM on December 16, a second run of CH47s and one company of HULDs would have been bringing in additional loads of ammunition, mines, flares, wire, and the like, while the CH54s at army level, if available, would have been used to carry heavier equipment such as 88mm. anti-tank and 75mm. antitank guns, heavy mortars, etc. If army helicopters were not available, the corps CH47s would have been used to meet logistics requirements for the forces outposting Bastogne with sufficient HULDs available to lift another battalion to bolster Bastogne's defenses if needed.

Thus, by 9:00 AM on December 16, a sizable force of Germans with extensive antitank defenses would have outposted the hills of Bastogne to await the arrival of the advance units of LXVII Corps.

It must be remembered that the weather on the 16th precluded Allied high performance aircraft operations. Hence German helicopters, flying under a situation of almost complete Allied surprise, could have flown their troop-carrying missions with little US interference. The fog and low cloud cover on the 16th and 17th of December would not have prevented helicopter operations.

The Americans were completely surprised, and initially assumed that the German attack was only a minor diversion or spoiling attack. Thus, no major decisions concerning the German advance were made for some 12 hours, other than to defend and to commit local reserves as needed. By the evening of December 16 it became clear that a major German offensive was under way, but it was not until the evening of December 17 that theater reserves (101st Airborne and 82nd Airborne Divisions) were released for commitment. The area selected for assembly, initially for both airborne divisions, later for the 101st Airborne only, was Bastogne, because of its central location and excellent road net.

By the evening of December 17, the Germans would have had a full 36 hours to perfect and reinforce the defenses of Bastogne. An Allied helicopter operation at the earliest could have been mounted at first light on December 18, by that time far too late to achieve anything but disaster. The situation would have been the same, even if the Allied reaction were 12 or 24 hours faster than was actually the case. The net result, if we assume that the other German corps had mounted similar helicopter operations, might well have been a decision not to try to halt the German advance in the Ardennes, since the key road and rail centers, bridges, and defiles had been seized at the outset of the attack. The Germans would have advanced too far, and thus the best course of action for the Allies would probably have been to fall rapidly back behind the Meuse River barrier.

Evaluation

In essence, an analysis of the Ardennes campaign revolves around a few key areas and installations, and the ability of the Germans to seize these before the Americans had an opportunity to defend them or destroy them. In each instance the Americans arrived simultaneously, or just ahead of the Germans. Vital bridges were

blown in time to prevent seizure. Yet in every instance, the particular key bridge, defile, or town was considered as so far behind the front on December 16 that it was unoccupied or undefended.

Consequently, a carefully planned helicopter assault in the areas of the Fifth and Sixth Panzer Armies at H-hour would have landed German troops unopposed. With these key areas in German hands, the German Panzers would have been able to roll to the Meuse, and possibly beyond, in a major German victory. Because of the almost complete surprise achieved, and the Allied frame of mind believing a German offense next to impossible, Allied reaction when it did get organized, would still have been too late though perhaps not 24 to 36 hours too late.

Logistics difficulties plagued the Germans almost from the outset. Forward units kept running out of gas. In certain instances they were able to keep moving only by sending their own trucks back many miles, or by raiding dumps. In other instances units were immobilized for as long as 48 hours before getting sufficient gasoline to mount an attack, which might otherwise have succeeded.

German artillery ammunition was severely curtailed for two reasons--first because the artillery trains were mostly horse-drawn and could not keep up with the more rapidly moving elements, and secondly because of a general shortage. In contrast the Allies never suffered shortages of either fuel or ammunition, except briefly at St. Vith and Bastogne.

The introduction of helicopters of the CH47 and CH54 variety would have made an enormous difference in the German ability to supply forward units, particularly so in the early days of the attack, when momentum had to be maintained at all costs and when the weather precluded Allied fighter interference.

Both sides used parachute supply drops, the Germans to assist Task Force Pieper and the Allies at Bastogne. Neither drop was wholly successful. Had helicopters been present, a much more effective supply situation would have been possible. However, for the Allies helicopters would have been frosting on the cake whereas for the Germans they might have made the difference between success or failure for the entire offensive.

HELICOPTERS AVAILABLE UNDER CURRENT TO/E

	<u>No.</u>	<u>Type</u>	<u>Cargo</u>	<u>Lift</u>	<u>Personnel</u>
<u>INF DIV</u>					
	34	OH6	---		3*
	19	HU1B	2800 lbs* or		8*
	<u>35</u>	HU1D	<u>3056 lbs*</u> or		<u>11*</u>
Total helicop- ters in Inf Div	88	Total lift	80 tons or		537 persons

Armored DIV

	34	OH6	---		3*
	13	HU1B	2800 lbs* or		8*
	<u>10</u>		<u>3056 lbs*</u> or		<u>11*</u>
Total	<u>57</u>		<u>33 tons</u> or		<u>214 persons</u>

Total CORPS

	75	HV1D	3056 lbs* or		11*
	<u>16</u>	CH47	<u>10,067 lbs*</u> or		<u>33*</u>
Total	<u>91</u>		<u>194 tons</u> or		<u>1353 persons</u>

(1 Aviation Bn of 3 light helicopter companies and 1 medium company)

ARMY

	25	HU1D	3056 lbs* or		11*
	16	CH47	10,067 lbs* or		33*
	<u>9</u>	CH54	<u>20,000 lbs*</u>		<u>---</u>
Total	50		207 tons or and 90 tons		703 persons

(1 Aviation Group Hqs with a helicopter battalion of one light, one medium, and 1 heavy company)

*per helicopter

The Predictive Possibilities

The preceding analysis suggests that there may be considerable value for analytical and predictive purposes in postulating the introduction of modern mobility means into specific historical examples of combat--if the circumstances, weapons, equipment, and doctrinal procedures at the time of the example are not too dissimilar to those of modern combat. From the results of the example considered above, it seems reasonable to assume that this can be done--and far more exhaustively--for a number of operations of World War II and the Korean War. In the light of the variety of circumstances of combat in these two wars, as well as the availability of very complete records, it would appear possible to apply this technique to most of the general kinds of circumstances in which future operations could be expected to take place.

There appear to be two major ways in which the technique could be employed. First would be an analysis of modified results, along the lines followed in the above example. Second, would be to prepare a wargame scenario, based upon the situation at the outset of the engagement selected, with modern mobility means introduced. During and/or after the play of the wargame, the manner in which the actual results of the engagement differ from the wargame results could then be analyzed thoroughly.

We believe, however, that a comparison of the wargame results with the actual results might be misleading unless there were also available for comparison the results of a wargame in which the actual conditions of the battle have been adhered to as closely as possible. Otherwise conclusions might be drawn with respect to the changes caused by the introduction of modern weapons which, in fact, are merely reflections of changes which occur simply in trying to translate reality into wargames.

CONCLUSIONS

It is concluded that:

1. An examination of tactical mobility in history will permit the development of factors or principles applicable to modern tactical mobility, and which will assuredly facilitate qualitative description of the relationship of tactical mobility to combat effectiveness.
2. It is probable that, utilizing preliminary work already done by HERO in earlier studies,* these same, or comparable, factors or principles can be utilized to develop a methodology whereby the relationship of tactical mobility to combat effectiveness can be expressed in quantitative terms.
3. It will be useful to examine a broad sweep of military history in the development of principles or factors applicable to modern tactical mobility.
4. It will be possible to postulate realistically the introduction of modern mobility capabilities in specific historical examples from relatively recent military history, in order to determine how enhanced mobility for both sides might have affected the outcome of the operations. The predictive value of this procedure appears to be high, whether carried out in purely analytical terms, or by means of wargames.
5. This study will provide a useful base for further, comprehensive, methodological development.

*"Historical Trends Related to Weapon Lethality," and "Historical Analysis of Wartime Replacement Requirements; Experience for Selected Major Items of Combat Equipment."

Appendix A

ORIGINAL STUDY PROPOSAL

DEVELOPING A METHODOLOGY TO DESCRIBE THE
RELATIONSHIP OF MOBILITY
TO COMBAT EFFECTIVENESS

DEVELOPING A METHODOLOGY TO DESCRIBE THE RELATIONSHIP
OF MOBILITY TO COMBAT EFFECTIVENESS

(A HERO Study Proposal)

Study Objective

The Historical Evaluation and Research Organization (HERO) proposes to undertake a study for the Research Analysis Corporation (RAC) which will examine the extent to which mobility has historically been related to the combat effectiveness of land forces. In this study conclusions will be drawn as to the possibility of deriving from historical experience a methodology for determining how increased mobility can change the combat effectiveness of ground combat elements, ranging from the corps to the battalion.

Background

In a study entitled "Historical Trends Related to Weapon Lethality," prepared for the US Army Combat Developments Command, HERO developed a method for evaluating any military weapon in terms of theoretical Lethality Indices. The validity of the method and the practical applicability of the Lethality Indices derived were substantiated in comparisons of certain elements of combat (firepower, mobility, dispersion) in typical combat deployments of forces in the Napoleonic Wars, Civil War, World War I, and World War II. A continuation of this line of investigation should permit definite conclusions as to the extent to which the relationship between mobility and combat effectiveness can be expressed in both qualitative and quantitative terms.

HERO has also recently completed a study for RAC on "Historical Analysis of Wartime Replacement Requirements Experience for Selected Major Items of Combat Equipment." This study was particularly relevant to the proposed mobility-combat effectiveness study in two respects: (1) It revealed the availability of a

wealth of primary source data on operations of regiments, divisions, and higher units in World War I, World War II, and Korea, data which has been relatively little explored or exploited for analysis of current technical and doctrinal problems of land combat; and (2) It provided HERO with considerable experience in relating, and evaluating, qualitative and quantitative elements of combat.

HERO is currently engaged in two other studies which are expected to suggest further useful areas of exploration, or specific historical examples, for the mobility-combat effectiveness study. One of these, for the Office of the Assistant Secretary of Defense (Systems Analysis) is an analysis of armored combat experience during and since World War II. The other is a study for RAC to produce "Average Casualty Rates for War Games, Based on Historical Combat Data."

Study Concept

HERO will undertake a brief and selective review of modern military history which has relevance to the interrelationship between mobility and combat effectiveness. Major emphasis will be placed upon examples in Europe, the Middle East, and Southeast Asia--although other relevant examples will also be considered.

Based upon this review, three areas of analysis will be surveyed in as much detail as time permits:

1. The process of assimilation of new means for increasing mobility of combat units, and the attendant impact upon their combat effectiveness, will be studied to ascertain the extent to which a methodology, based upon historical example, can be evolved which would predict the influence of mobility in future combat situations. The extent of applicability of such a methodology will be analyzed as thoroughly as time permits. This analysis will include an exploration of the possibility of developing a set of principles which could be applied to Army-wide mobility combat requirements in the 1970-1980 period and--if indicated--will suggest a method for developing the principles.

2. Historical examples in which mobility was of special significance in influencing the outcome of an operation or series of operations will be studied to the extent data and time permit.

Surveys of these examples will indicate explicitly the manner in which changes or differences in mobility affected the outcomes.

3. The possibility of postulating the introduction of modern mobility capabilities in specific historical examples will be investigated as a possible analytical tool, in order to determine how enhanced mobility might have affected the outcome of such campaigns, and what the costs or savings might have been through such enhancement. The predictive value of such a methodological procedure will be assessed.

Operational Work Plan

Because of the limited time available for the completion of this study, HERO will not attempt to make intensive or exhaustive historical research in depth. Members of the HERO Permanent and Associate Staff, and Special Consultants, will survey relevant historical data previously developed in HERO studies and will refer to other general and secondary sources to the extent necessary. The survey will cover three general historical eras: (1) Prior to World War I; (2) World War I through World War II; and (3) Since World War II. This effort will take no more than four weeks. In close coordination with the scholars working on the basic historical data, work will be begun on the analytical areas indicated above, under "Concepts." Completion of each of these three sub-analyses will be completed within ten days of the completion of the drafts of the basic historical surveys.

A Review Panel of Senior scholars and military specialists will thoroughly review the historical surveys and the three sub-analyses, to assure their integration into a cohesive report, responsive to the requirements which RAC has established.

Throughout this process close coordination will be maintained with responsible cognizant personnel from RAC. On the assumption that work on the study can begin on or about 27 December, it is anticipated that within four weeks (or on or about 24 January) the historical survey will be completed in draft, and the major outlines of the three sub-analyses will be complete. An informal statement of progress will be prepared at that time, for purposes of internal HERO review and control as well as to keep RAC informed of the progress and status of the study.

The analytical portions of the study should be completed in draft on or about 31 January. The Review Panel will complete its

work during the week of 6-10 February. A Final Report will then be submitted to RAC on or before 17 February.

Personnel

Appendix C contains a list of Associates and Special Consultants who have been invited to participate in this study, if the contract is awarded. Attached to that appendix are resumes of each individual listed.

Budget

Appendix B contains the tentative budget for carrying out the proposed study in accordance with the concept and work plan indicated above. This provides for a total of 74 professional man-days of effort, at a total cost of \$9,929. HERO will submit to RAC a voucher for a progress payment of one-half of this sum at the time the informal statement of progress is submitted (on or about 24 January, if the suggested timing is adhered to). A final voucher will be submitted at the time of submission of the final report.

Appendix A

OUTLINE

	<u>Man-days</u>
A. Introduction--Purpose and Scope of Study	Negl.
B. Basic Historical Data	21
1. Before 1914	
2. 1914 through 1945	
3. Since 1945	
C. Analysis	30
1. The extent to which methodology can be based on historical example	
a. The assimilation process	
b. The question of interrelationships	
c. Quantitative and qualitative factors	
d. Principles relating to mobility	
2. Historical summaries	
(To be selected in consultation with RAC, then elaborated to the extent time and data permit)	
3. Transfer of modern mobility data to historical examples	
a. The issues and problems of data transfer	
b. Elaboration of one example	
c. The predictive possibilities	
C. Conclusions	5
/Additional time requirements:	6
Planning and Coordination	6
Review	6
Editing	
Total	74 man-days

Appendix B

COMPARISONS OF COMBAT DATA RELATIONSHIPS FOR FOUR WARS*

1. Lethality Indices for Selected Weapons
2. Lethality Statistics for Selected Napoleonic War Battles
3. Lethality Statistics for Selected Civil War Battles
4. Composition of Type Forces (Napoleonic Wars, Civil War, World Wars I and II)
5. Comparison of Theoretical and Actual Lethality Figures for 100,000-man Type Forces (Napoleonic Wars, Civil War, World Wars I and II)
6. Comparison of Theoretical and Actual Lethality Figures for Selected Weapons (Napoleonic Wars, Civil War, World Wars I and II)
7. Basic Lethality, Dispersion, and Mobility Factors (past, present, and future)

*Excerpts from HERO study, "Historical Trends Related to Weapon Lethality."

LETHALITY INDICES FOR SELECTED WEAPONS

<u>Weapons</u>	<u>Lethality Index</u>
Hand-to-hand (sword, pike, etc.)	20
Javelin	18
Ordinary bow	20
Longbow	34
Crossbow	32
Arquebus	10
17th Century musket	19
18th Century flintlock	47
Early 19th Century rifle	36
Mid-19th Century rifle with conoidal bullet	154
Late 19th Century breechloading rifle	229
Springfield Model 1903 rifle (magazine)	778
World War I machine gun	12,730
World War II machine gun	17,980
16th Century 12-pounder cannon	43
17th Century 12-pounder cannon	229
Gribeauval 18th Century 12-pounder cannon	3,970
French 75mm gun	340,000
155mm GPF	474,000
155mm "Long Tom"	533,000
105mm Howitzer, M-1	644,000
World War I tank	68,300
World War II medium tank	2,203,000
World War I fighter-bomber	229,200
World War II fighter-bomber	3,037,900
V-2 ballistic missile	861,000
20 Kiloton nuclear airburst	48,550,000
One megaton nuclear airburst	211,500,000

Enclosure 4--LETHALITY STATISTICS FOR SELECTED NAPOLEONIC WAR BATTLES

Battle	Side	Forces	Area in Miles ²	Density/ Miles ²	% Cav.	Gun/Man	Guns	Number Rifles/ Muskets	Total Losses	%	Lethality/ Muskets	Lethality/ Cannon
Austerlitz 2 Dec 1805 (8.5 hrs)	Fr* Al	75,000 89,000	13.5 13.5	5,500 5,500	30 16	.003 .003	225 265	43,200 62,500	7,000 27,500	9.3 31	.222 .039	42.8 9.25
Jena 14 Oct 1806 (9 hrs)	Fr* Pr	90,000 50,000	17.5 9	5,150 5,550	30 23	.0035 .0035	315 175	51,030 31,500	7,000 20,000	7.8 40	.156 .077	27.2 14.0
Auerstadt 14 Oct 1806 (9 hrs)	Fr* Pr	30,000 50,000	4.5 10.1	6,700 4,950	30 23	.0035 .0035	105 175	17,010 31,500	7,000 20,000	23.4 40	.411 .071	66.6 14.0
Borodino 7 Sep 1812 (12 hrs)	Fr* Rus	130,000 121,000	6? 7?	21,666 17,300	21 17	.005 .004	650 484	80,730 80,775	27,000 50,000	20.7 41.2	.215 .116	26.9 19.52
Dresden 26-27 Aug 1813 (14 hrs)	Fr* Al	100,000 150,000	6 8	16,666 18,750	20 17	.0035 .0035	350 525	65,700 102,600	10,000 35,000	10 23.3	.186 .034	35 6.66
Leipzig 16-18 Oct 1813 (24-36 hrs)	Fr Al*	180,000 300,000	9 11	20,000 27,270	20 17	.0035 .0035	630 1,050	118,260 205,200	62,000 53,000	34.4 17.7	.156 .105	29.4 20.6
La Rothiere 1 Feb 1814 (7 hrs)	Fr Al*	28,000 78,000	2.5 4	11,200 19,500	23 11	.004 .003	112 234	17,388 58,266	5,000 6,000	17.9 7.7	.121 .030	18.71 7.471
Waterloo 16 Jun 1815 (4-10 hrs)	Fr Al*	72,000 129,000	4 8.5	18,000 15,200	32 22	.004 .003	288 387	38,880 83,592	32,000 22,500	44.5 17.5	.199 .151	36.1 28.8
Averages:	Fr Al Av Type	88,200 120,100 104,150 100,000	7.9 8.9 8.4 8.05	11,200 13,600 12,400 12,400	30+ 30- 30 30		336 412 374 350	51,620 70,800 58,882 56,700	19,600 29,200 24,400 23,400	22.2 24.3 23.4 23.4	.198 .097 .148 .148	30.4 16.7 23.6 23.6

Lethality of type army: 21,080
(See Enclosure 7)

*Victor

Enclosure 5--INFANTRY STATISTICS FOR SELECTED CIVIL WAR BATTLES

Battle	Side	Forces	Area in Miles ²	Density/ Miles ²	% Cav.	Guns/Man	Guns	Number Rifles	Total Losses	%	Lethality /Rifle	Lethality /Cannon
Shiloh 6-7 Apr 1862 (15-20 hrs)	U*	62,682 40,335	5 4	12,500 10,000	13.4 13.4	.003 .003	188 121	45,470 29,259	13,047 10,694	20.9 26.5	.202 .375	5.12 9.70
Antietam 17 Sep 1862 (12 hrs)	U C	80,000 45,000	10.5 9.5	7,600 5,000	13.4 13.4	.003 .003	240 135	59,012 32,463	12,410 13,724	15.5 30.5	.200 .329	5.15 8.27
Fredericksburg 13 Dec 1862 (12 hrs)	U C*	106,000 72,500	10 7.5	10,600 9,650	13.4 13.4	.003 .003	318 217	76,892 48,600	12,653 5,209	11.9 7.2	.058 .2065	1.47 5.24
Stones River 31 Dec 1862 - 2 Jan 1863 (36 hrs)	U C	41,400 34,732	3.5 3.4	11,800 10,000	13.4 13.4	.003 .003	124 104	29,135 25,198	12,906 11,739	31.2 33.8	.344 .442	8.49 11.2
Chancellorsville 1-4 May 1863 (36 hrs)	U C*	101,000 57,352	12.0 10.5	8,440 5,450	13.4 13.4	.003 .003	303 172	73,265 37,914	16,792 12,764	16.6 22.2	.1497 .339	3.78 8.78
Gettysburg 1-3 Jul 1863 (30 hrs)	U* C	88,289 75,000	4 6	22,000 12,500	13.4 13.4	.003 .003	264 225	64,061 54,405	23,049 28,063	26.1 37.4	.377 .364	9.57 9.22
Chickamauga 19-20 Sep 1863 (24 hrs)	U C*	58,222 66,326	3.5 4.5	16,600 14,700	13.4 13.4	.003 .003	174 198	42,246 48,149	16,170 18,454	27.8 27.8	.386 .288	9.55 7.34
Chattanooga 23-25 Nov 1863 (14 hrs)	U* C	56,359 46,165	6 6	9,400 7,700	13.4 13.4	.003 .003	169 138	40,884 33,497	5,824 6,667	10.3 14.5	.140 .150	3.56 3.79
Averages:	U C Av. Type	74,200 54,800 64,500 100,000	6.8 6.03 6.45 10.3	10,900 8,500 9,750 9,750			223 164 193 300	53,829 39,843 46,300 72,540	15,323 13,414 14,369 22,290	20.6 24.5 22.3 22.3	.214 .332 .273 .273	5.44 6.35 6.95 6.95

*Victor

Lethality of type army: 25,225
(See Enclosure 7)

Enclosure 6

COMPOSITION OF TYPE FORCES

Napoleonic Wars

On the basis of data reported or calculated in early portions of the study, a typical Napoleonic army of 100,000 men would be composed as follows:

Cavalry:	30,000 men
Artillery:	7,000 men, 350 guns
Infantrymen with muskets:	56,700 men
Others:	<u>6,300 men</u>

Total 100,000 men, 350 guns

Using the lethality indices calculated earlier, this type army has a total theoretical lethality index of 5,500,000, or 5.5M.

Civil War

On the basis of data reported or calculated in early portions of the study, a typical Civil War army of 100,000 men would be composed as follows:

Cavalry:	13,400 men
Artillery:	6,000 men, 300 guns
Infantry riflemen:	72,540 men
Others:	<u>8,060 men</u>

Total 100,000 men, 300 guns

Using the lethality indices calculated earlier, this type army has a total theoretical lethality index of 14,300,000, or 14.3M.

World War I

The data shown below has been compiled from various sources*, and is indicative of a type American Army corps of three divisions, organized and equipped as were US forces in the AEF, in France, in 1918.

Infantry Division:	28,000 men, of whom 14,550 were riflemen 72 artillery pieces (75mm and 155mm) 100 mortars (or equivalent), which in turn are evaluated as averaging the equivalent of 10 light artillery pieces in lethality 1,000 machine guns, light machine guns, or automatic rifles
Supporting Corps Troops:	1,500 riflemen 154 artillery pieces (or equivalent) 1,000 machine guns 100 tanks

Totals for type corps:

riflemen:	45,000
machine guns:	4,000
cannon:	400
tanks:	100

Using the lethality indices calculated earlier, this type corps has a total theoretical lethality index of 232,800,000, or 232.8M.

*Ayres, Leonard P., The War with Germany; A Statistical Summary, Washington Govt. Printing Office, 1919; The Army Almanac, U.S. Govt. Printing Office, 1950; McEntee, Girard L., Military History of the World War, Scribner, NY, 1937; Stamps, T. Dodson, and Vincent J. Esposito, A Short Military History of World War I, USMA, West Point, 1950, etc.

World War II

The data compiled below has been compiled and adapted from FM 101-10, 1 August, 1945, for a type corps of three infantry and one armored division, with attached air support:

Infantry Division: 14,037 men, of these 6,349 riflemen
70 light infantry guns) evaluated
144 mortars) as averaging 1/10
equivalent
of light
artillery
piece in
lethality
87 artillery pieces (including
105mm infantry guns)
866 machine guns

Armored Division: 10,670 men, of these 2,040 riflemen
1,841 machine guns
195 light infantry guns and mortars
(equivalent to 20 light artillery pieces)
89 artillery pieces
195 medium tanks
77 light tanks (evaluated as
equivalent to 15 medium tanks
in lethality)
50 armored cars (evaluated as equivalent to 6 medium tanks in lethality)

Supporting Corps 3,300 riflemen
Troops: 430 machine guns
80 artillery pieces
50 tanks
50 supporting aircraft

Totals for type corps:

riflemen:	30,738
machine guns:	5,694
artillery:	537
tanks:	266
fighter-bombers:	50

Using the lethality indices calculated earlier, this type corps has a total theoretical lethality index of 1,280,500,000, or 1,280.5M.

Enclosure 7 ... COMPARISON OF THEORETICAL AND ACTUAL LETHALITY
FIGURES FOR 100,000-MAN TYPE FORCES

	Napoleonic War		Civil War		World War I		World War II	
	Theo- retical*	Actual Per Battle	Theo- retical*	Actual Per Battle	Theo- retical*	Actual Per day	Theo- retical*	Actual Per Day
Small Arms Lethality for 100,000	2.71	8,390	11.05	19,500	40.0	3,070	28.0	2,700
Artillery Lethality for 100,000	1.38	8,250	1.19	2,065	136.0	11,300	333.0	10,800
Cavalry Lethality	1.41	4,440	2.06	3,660				
Machine-Gun Lethality for 100,000					50.7	3,070	86.4	2,700
Tank Lethality					6.1	***	649.0	***
Aircraft Lethality							158.4	***
Total Lethality 100,000 men	5.5	21,080	14.3	25,225	232.8	17,440	1280.5	16,200

**Figures are included with both artillery and small arms-machine gun totals

*In millions.

Enclosure 8

COMPARISON OF THEORETICAL AND ACTUAL LETHALITY FIGURES
FOR SELECTED WEAPONS

Weapon	Theoretical Lethality Index	Actual Battlefield Lethality Value/day			
		Napoleonic War	Civil War	WW I	WW II
Saber/bayonet	20	.139	.131		
Flintlock Musket	47	.139			
Rifle, musket & conoidal bullet	154		.131		
Magazine Rifle	780			.068	.088
12-pounder Cannon	3,970	23.6	3.31		
Machine Gun (WW I)	12,700			.768	
Machine Gun (WW II)	17,900				.476
French 75	340,000			28.3	
105mm How.	644,000				20.1
Tank (WW I)	68,300			?	
Tank (WW II)	2,203,000				?
Aircraft (WW II)	3,037,000				?

BASIC LETHALITY, DISPERSION, AND MOBILITY FACTORS
(Revised)

Item Item	Napoleonic Wars	Civil War	World War I	World War II	1970?
Area of 100,000 men (square miles)	8.05	10.3	99	1,290	33,500
Average frontage of 100,000 men (miles)	5.7	6.4	9	34	160
Average depth of 100,000 men (miles)	1.4	1.6	11	38	209
Average diagonal for 100,000 men (miles)*	5.9	6.6	14.2	51	264
Lethality Index Totals (in millions)	5.5	14.3	232.8	1,280.5	32,500
Movement rate for major reserves (mph)**	2	2	2	15	x****
Time to cross diagonal (hours)	2.95	3.3	7.1	3.4	y****

* Maximum distance from which reserves could be committed within the area of sector

** For the Napoleonic, Civil, and First World Wars, major reserves within the sector of a 100,000 man force were committed on foot, at an average rate of 2 mph. For World War II, major reserves were committed within such a sector by truck, at an average rate of 15 mph. For a future war in 1970, see note below.

*** If x is 25, y is 10.5; if x is 50, y is 5.3; if x is 60, y is 4.4.

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COMPARATIVE ANALYSIS OF ARMORED CONFLICT EXPERIENCE

A Draft Final Report

submitted by the

Historical Evaluation and Research Organization
2233 Wisconsin Avenue, N. W.
Washington, D. C., 20007

17 March 1967

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The Saar Campaign, 8 November-7 December 1944
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Bastogne, 18-20 December 1944
Alam Halfa, 31 August-3 September 1942
Chouigui Pass, November 1942
Targul Frumos, Rumania, May 1944
India-Pakistan, August-September 1965 (U) (submitted
separately herewith, HERO Log H-S-32; to appear
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III. ANALYSIS

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APPENDICES

A -- The Tank Engagements

France-Flanders, 1940
GOODWOOD, 18-21 July 1944
Arracourt, 19-22 September 1944 (submitted previously)
The Saar Campaign, 8 November-7 December 1944 (submitted
previously; 1 additional copy herewith)
St. Vith, 17-23 December 1944
Bastogne, 18-20 December 1944

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Alam Halfa, 31 August-3 September 1942 (submitted previously; 2 additional copies herewith)
Chouigui Pass, November 1942 (submitted previously; 2 additional copies herewith)
Targul Frumos, Rumania, May 1944
India-Pakistan, August-September 1965 (U) (submitted previously, HERO Log H-S-24; to appear in classified annex)

B -- Notes on Relevant Studies (U) (submitted separately herewith, HERO Log H-S-31; to appear in classified annex)

C -- Comments on German Military Documents

D -- Terms of Reference (not submitted with this draft)

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I. METHODOLOGY

Selection of Armor Actions for Study

The criteria for actions to be studied were those set by Systems Analysis, Department of Defense (SA/DOD), to meet its research needs. They were as follows:

1. The actions were to be primarily tank-against-tank. The client expressed strong interest, however, in the effect of supporting arms upon such armor battles.

2. If possible, large numbers of tanks should be involved, preferably an armored division or more on each side.

3. Terrain must be relatively open; no actions in jungle or excessively mountainous terrain should be considered.

About halfway through the study, in further discussions with representatives of SA/DOD, the following additional desirable criterion was set forth:

4. If possible, at least one action treated should be a battle in which one side was defending prepared positions against a determined major attack.*

*SA/DOD also expressed interest in wearout and mechanical breakdown during or at the end of periods of breakout and pursuit. The study participants agreed, however, that since such investigation required a very different kind of research process from the detailed investigation of individual armor actions already approaching completion, it was not feasible in the time available to attempt it. Such data could best be obtained, it was agreed, by following one or more armored divisions day by day through a long period including periods of both combat and noncombat.

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As a basis for selecting the actions to be studied, an overall list was first prepared of a large number of varied armor actions in World War II.* The list was drawn up by the senior study participants in a planning conference for the study. It included five Northwest Europe actions during 1944-1945, three Mediterranean Theater actions, three involving British tanks in the North African Western Desert, six Eastern Front actions, and three other operations--the German invasion of France and Belgian Flanders in 1940, the India-Pakistan tank engagements of 1965, and the Israeli invasion of the Sinai Peninsula in 1956.

It was decided that the actions to be treated in the study would be chosen from this overall list on the basis of availability of records to provide the detailed strength and loss data needed for meaningful quantitative analysis. The results of record searching at the Federal Records Center, Alexandria, and at the US Army Armor Center at Fort Knox, together with consultations with historians of the Office, Chief of Military History, and the Document Reference Library of the Research Analysis Corporation, resulted in the following decisions.

1. Eastern Front. The tank battles on the Eastern Front would have been ideal for purposes of the study because of the large numbers involved and the open terrain. Unfortunately, it

*Korea was excluded because of the small numbers of tanks involved in individual actions.

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was conclusively determined that there are no German records available in this country that deal with events at the battalion level, and no detailed strength and loss figures even at division level.* Soviet records, of course, are not available. Late in the study, a study participant did prepare a paper on the Eastern Front battle of Targul Frumos, Rumania, on the basis of B.H. Liddell-Hart's interview with General Hasso von Manteuffel, who commanded the German forces in the battle. Although the account was one-sided, and probably not fully objective, it appeared to be sufficiently accurate and specific to be included.

2. Northwest Europe.

a. Operation GOODWOOD, August 1944, was chosen because of its close conformity to the criteria for the study, despite the fact that paucity of records would make thorough quantitative analysis impossible. The operation involved large numbers of tanks (more than 900 British tanks), in a determined attempt to break through a well-prepared defense in depth. There are no British primary sources (after action reports, etc.) in this country, and no German records bearing on the action in this country. British studies of the action that are available are focused in such a way that they do not provide the data needed for this study. Adequate

*Such records apparently were in this country, but were returned to West Germany without having been microfilmed.

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records to complete this substudy are available in England and in West Germany.

b. The action near Arracourt, September 1944, was selected because of relatively good official records and availability of participants for interviews.

c. The US defensive actions in the "Battle of the Bulge" at St. Vith and Bastogne were chosen as examples of armor against armor in defense. More documentary data was available for St. Vith than for Bastogne, but the drama of both actions aroused so much interest at the time that a good deal of material based on survivors' accounts has been published and was utilized.

d. Good material was found of the Saar Campaign of November-December 1944, and this action, not on the original list, was added.

e. No data could be found on the German attack in Alsace, January 1945, and it was removed from this list. It was decided that it was not feasible to treat the breakout-and-pursuit period (Avranches-Falaise) of August 1944, as too many confused, individual engagements were involved to make analysis possible. As noted above, it was decided that study of breakout and pursuit, and the presumably attendant problems of mechanical reliability and endurance, could be better treated in a different kind of study.

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3. Mediterranean. A well-documented small-unit action at Chouigui Pass in Tunisia, November 1942, was selected. Data on the other Mediterranean actions that had been considered was not adequate, due to nonavailability of German records.

4. Western Desert. British defense of Alam Halfa against Rommel in summer 1942 was chosen. It was felt that since it was a determined tank defense in prepared positions against a vigorous assault it was especially well suited for the study.

5. Other operations. Through the cooperation and help of the Defense Intelligence Agency, reasonably good data was available for the India-Pakistan actions, and a classified paper was prepared. The France-Flanders campaign, which was treated largely on the basis of published secondary materials, was found to provide considerable material for analysis, with adequate cumulative figures available for the whole campaign, and enough data available for specific operations, down to the small-unit level in one case, to provide accounts of the campaign at four different levels.

The ten actions finally selected, regrouped on a geographic rather than theater-of-operations basis were as follows:

A. Northwest Europe, World War II

1. France-Flanders, 1940
2. GOODWOOD, 18-21 July 1944
3. Arracourt, 19-22 September 1944
4. The Saar Campaign, 8 November-7 December 1944
5. St. Vith, 17-23 December 1944
6. Bastogne, 18-20 December 1944

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B. North Africa, World War II

1. Alam Halfa, 31 August-3 September 1942
2. Chouigui Pass, November 1942

C. Eastern Front

1. Targul Frumos, Rumania, May 1944

D. Post-World War II

1. India-Pakistan, August-September 1965

Assembling the Material

The data from US records on the tank actions selected was collected by those senior study participants who had been given responsibility for preparing papers on the actions (Andrews, Crosby, Nihart) with the help of research assistants. The research assistants, with the help of the Federal Records Center staff, searched the records available at the Center for the units involved, for the time periods of the actions. After action reports, division histories, unit diaries, journals, and periodic reports (G-2, G-3, G-4) were the basic sources for strength and loss figures. The contemporary accounts of the actions were also useful, as were comments on the effectiveness of US and enemy tanks.

German records in this country are discussed in Appendix C, attached. The German records were searched by a German-fluent senior staff member of HERO, assisted by a German-fluent research assistant.

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A trip to the Fort Knox Armor Center by one of the senior participants resulted in the selection and loan to HERO by the Armor Center of 21 unpublished monographs, several published works that had been difficult to obtain in this area, and 14 after action reports, other unit reports, and miscellaneous papers. This material was all examined, and much of it was found useful for the study.

The staff of the Historical Services Division and of the Histories Division of the Office, Chief of Military History, made available a number of unpublished monographs that were especially helpful in filling in the German side of several actions. Especially valuable was the advice of these experienced historians and researchers as to which materials were available elsewhere, and which simply were nonexistent or not available in this country.

The staff of the Document Reference Library of the Research Analysis Corporation made available, and in several cases borrowed for the study participants, various materials, especially classified studies on the use of armor. These, while generally adding nothing to the data for specific operations, were valuable for general background, including as they did such material as overall statistics on tank losses by causative agent, theoretical work on tank roles, and efforts to derive desirable strength ratios of opposing tanks. Other similar material was borrowed for the study

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participants by SA/DOD. Much of this material is listed and briefly discussed in Appendix B (contained in classified annex).

About a dozen personal interviews with action participants were also conducted by one of the study participants (Colonel Crosby). Although these could not, of course, yield numerical data on strengths and losses, they brought out several otherwise unrecorded and very significant factors in the battles (as, for instance, the use of white phosphorus at Arracourt). Action participants were able to suggest sources of data in some cases, and at least one action participant had personal records in his possession that did give some detailed numerical data.

Published secondary sources were also used, the most useful being the Office, Chief of Military History, volumes in the series "US Army in World War II."

A good deal of research was also required to obtain in detail the characteristics of the tanks that took part in the actions studied. A most valuable source for German World War II tanks was a mimeographed British work, with photographs, "Illustrated Record of German Army Equipment, 1939-1945," Vol. III (M.I.10, The War Office, 1947) lent to HERO by RAC. B.H. Liddell-Hart's book, The Tanks, contains less detailed charts of characteristics for World War II tanks of all nations except the Soviet Union. Armor: A History of Mechanized Forces by R.M. Ogorkiewicz (New York: Praeger, 1960) provided some useful information on Soviet tanks,

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but no detailed data. Handout data sheets published by US Army Ordnance on US and foreign tanks were also used. Contemporary US intelligence reports on German tanks, found at the Federal Records Center gave tank characteristics as observed in combat and derived from captured tanks. In general, the sources agreed closely. A challenging research problem was the determination of which model of the eight models of the German Pz.Kpfw. IV, for example, was involved in a given action in which the sources report only "Mark IVs." Data on development and dates of introduction of the various models, given in "Illustrated Record of German Army Equipment" and Liddell-Hart, together with slim clues in contemporary accounts of the actions, and other sources, were helpful in satisfactorily resolving this problem.

Interpretation and Use of Data

Each of the ten actions treated has been presented in a paper that includes the following parts:*

1. A narrative account of the action.
2. An analysis of the action, with emphasis on the factors determining success of the winning side.

*Not all these items have yet been supplied for all actions, but all will be in the final report.

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3. A map of the battle area.
4. Numerical data on tank strengths and losses, presented in tabular format.
5. Data on tank characteristics for all types of tanks involved in the action, presented in tabular format.
6. A bibliography of sources.

The numerical data of items 4 and 5, above, have been presented in tabular formats adapted from samples provided by SA/DOD. One format shows tank strength and loss figures for a given action, and the other shows characteristics of the tanks engaged in the action. Following the suggestion of SA/DOD, the actions have been divided into phases in cases in which they fell naturally into such phases, and in which there was data in adequate detail to make such phasing reasonably accurate. (None of the phased charts is yet ready for submission, but they are being prepared for the final report. Preparing tables for each phase of an action raises some difficult problems, such as determining the frontage of an engagement phase.) It was also decided to present the characteristics of all tanks involved in a given engagement in one spreadsheet chart with the account of that engagement.

In most cases there were gaps in the data that could not be filled except arbitrarily. For example, it was known in one action that both heavy and medium tanks were engaged, but it was not possible to tell how many of the tank casualties were heavy and

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how many were medium. In no case except that of GOODWOOD did lack of data make it impossible to gain a clear picture of relative strengths and losses and to derive effectiveness quotients by use of the formula provided by SA/DOD. In the case of GOODWOOD, it was decided to submit the action without the unavailable German figures because of its special interest for the study.

In interpretation of data, a consistent attempt has been made to focus on two key points, central to the study and to the client's interest: (1) the advantage gained in each action from numerical superiority; (2) the advantage gained from qualitative superiority in specific tank characteristics. In a number of cases it was found that superior tactics, leadership, training, or good fortune was more significant in the outcome of the battle than either numerical superiority or overall qualitative superiority. In these cases, the question asked was, "What factors of numerical superiority, or what specific tank characteristics made it possible to successfully implement the superior tactics, or take advantage of the superior leadership, training, or luck?"

II. SUMMARIES OF TANK ACTIONS INVESTIGATED

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France-Flanders, May-June 1940

The Germans invaded the low countries and France in May 1940 and quickly won a stunning victory, despite substantial numerical inferiority (3,609 French and British tanks to 2,574 German tanks). The German tanks were also generally inferior in armor and firepower, although they were somewhat superior in mobility--and mobility in all its aspects was the key factor in this campaign.

The well-conceived German strategic plan called for a thrust down through the low countries which would draw the best French and British forces, whereupon the main German attack, 44 divisions strong and using most of the available German armor, would push through the Ardennes area and break through to the Channel, cutting off the Allied forces to the north. The plan worked smoothly. The French had thought the Ardennes impassable for armor, and had defended it so lightly that its roads were entirely adequate for the German tanks. The Meuse crossings were forced and the breakthrough accomplished with the support of strafing Stuka aircraft, whose devastating psychological effect substituted for the artillery which the German armored units had outrun.

German Breakthrough and Exploitation North of the Somme, 10-24 May 1940

In this classic campaign the Germans concentrated 2,683 tanks, which qualitatively were somewhat inferior in gunpower and

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and armor although superior in speed and range, against 2,160 French and British tanks. German losses were 1,080, an estimated two-thirds of which were repairable, to Allied losses of 2,060 which in addition to combat losses, included total losses due to capture or destruction to avoid capture. Determining factors were the German exploitation of concentration at the decisive point; tactical, operational, and technical surprise; and mobility in all of its forms, physical, mental, organizational, doctrinal, command-control-communications, and the use of firepower and terrain. Conversely, the Allies, although possessing an overall greater number of tanks in France (3,609 Allied to 2,574 German), dispersed their tanks in France, in the area of the campaign, and organizationally. Allied tactics, doctrine, command-control-communications, and mental preparation was also deficient for this new form of warfare. This 2-to-1 disparity of tank losses, while in favor of Germany and significant, does not tell the complete story, as this campaign destroyed France as a military power and drove Britain from the continent.

Rommel's 7th Panzer Division,
10-24 May 1940

The participation of Rommel's 7th Panzer Division in the campaign north of the Somme River provides a closer look at armored combat and its result. Rommel collided with both a French armored division and a British tank brigade, paced the

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overall German attack (along with Guderian), and had a better tank loss ratio than the aggregate of all German panzer divisions. This study estimates Rommel's losses for this campaign at 72, while losses inflicted by him on the Allies were 161. Indices of effectiveness were thus 2.47 for Rommel and .4 for the Allied units encountered. The same determinants obtained in this portion of the campaign as for the campaign as a whole.

A Group Franc South of the Somme,
June 1940

This small-unit action had a well-led and integrated French combat team launching a mobile counterattack from a defensive base and inflicting disproportionate losses on a German unit that had three times as many tanks but lacked reconnaissance or support. The French Group Franc consisted of 5 Somua tanks heavily armored for the time and armed with a very powerful 47mm. gun, 5 Panhard armored cars armed with 25mm. guns, 2 47mm. antitank guns, 2 25mm. antitank guns, heavy machineguns, and a motorcycle reconnaissance company. The Germans had 14 Pz.Kpfw. IV tanks with 30mm. of armor and a short 75mm. gun. The German tanks were the most powerful they possessed at the time, yet the French 47mm. guns easily penetrated them, while the German 75mm. gun of that time was only rarely effective against the 40mm. armor of the Somua. The Germans, without support or prior reconnaissance, blundered into the well-prepared and coordinated French defense and in fighting their way

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out of contact and around the position lost 4 tanks to the 47mm. antitank guns and 3 tanks to the Somua tanks' 47mm. guns while knocking out one Somua--a score of 7 to 1 in favor of an integrated organization employing appropriate tactics. French effectiveness was thus 20, while German was only .05.

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GOODWOOD, 18-22 July 1944

Operation GOODWOOD was a part of the Allied effort to break out of the Normandy beachhead in the vicinity of Caen. It is remarkable both for the effectiveness of preliminary aerial bombardment and for the misuse of tanks. British losses were very heavy (459 tanks lost or 36% of all engaged). German losses for this operation have not been found in the microfilmed records in the United States. The battle began with an extensive aerial bombardment which limited the initial response of the Germans to the British advance. However, as the British pushed further into the German defensive lines several weaknesses in their operational planning became apparent, while German defensive tactics were excellent. German armor and antitank guns were well placed to hit the advancing British tanks, which were trying to force the breakthrough without the aid of infantry. The British armor advanced beyond the range of supporting artillery fire; and the narrow attack zone bounded by minefields limited the number of tanks that could be committed and caused a severe traffic jam. GOODWOOD drew German armor off the US front and destroyed some of it; no breakthrough was achieved, but a continuation was made to the success of the later US breakthrough. British tank superiority (at least 4-1) and effective air bombardment resulted in a limited British advance.

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Arracourt, 19-22 September 1944

This tank battle near Arracourt, France, was won by Combat Command A of the US 4th Armored Division through superior leadership and tactics, despite a German numerical superiority of 5:3 (in the medium tanks that actually fought the battle), and despite the overall qualitative superiority of the German Mark IV (Pz.Kpfw. IV) and Mark V (Pz.Kpfw. V) tanks to the US M4. Responding to a German counterattack by the 111th and 113th Panzer Brigades, the US forces achieved a US-German loss ratio of 4:1 (87 German tanks lost to 21 US tanks lost). US leadership effectively used the principles of mass and maneuver, concentrating ~~their~~ tanks and launching repeated spoiling attacks, while the Germans wasted their tanks in piecemeal commitments.

The superior mobility of the US M4 on dry, firm ground, and its power-traverse, quickly turning turret, more than compensated for the greater penetration capability of the German tank armament --75mm. guns, 43, 48, and 70 calibers long. Low visibility due to fog prevented US air support that would otherwise have been available, but the fog also allowed the Americans to close to a distance at which their less powerful L/40 guns became effective. Well-coordinated use of the highly effective tank destroyers and of artillery support contributed to the success. US use of white phosphorus as a first round allowed quick adjustment of fire, forced

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several German crews to abandon their tanks, and allowed the US tanks to draw close without being seen.

The Saar Campaign, 8 November-7 December 1944

Bad weather was the most influential factor in the Saar Campaign, November-December 1944. Continual rain made the ground nearly impassable and poor visibility prevented air support. The aim of the US Third Army offensive was to clear the southern part of the Saar Valley and eventually to establish a bridgehead over the Rhine. In this operation, the US 4th Armored Division (271 tanks) was opposed by 9 German divisions, 2 brigades, and some miscellaneous units (145 tanks). The German Mark IVs, Mark Vs, and Mark VIIs were superior to the US M4s in flotation, gunpower, and armor protection. Despite their smaller force, the Germans fought a successful delaying action. They suited their tactics to take full advantage of the geographic and climatic conditions, while --because of these circumstances--the United States was engaged in an offensive for which tanks with marginal flotation were not well suited. Including 10 tanks that were recovered and returned to service, the US losses were 56 tanks to the German loss of 61. Thus although the Germans were outnumbered in tank strength almost 2:1, tank losses were almost equal for the two sides. Ten US M5s and 45 miscellaneous German tanks that were present were not suitable for action against opposing armor and antitank weapons, and if they

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are eliminated from consideration the German losses are actually less, by a ratio of 1-4, than those of the US force.

St. Vith, 17-23 December 1944

The mission of CCB of the 7th Armored Division at St. Vith was to hold at all costs in order to disrupt the German Ardennes offensive. Through use of excellent defensive tactics it did hold for six days against greatly superior German forces, delaying the Germans long enough to make certain the failure of the German offensive. Inadequate German planning allowed the German offensive spearheads to be held up by traffic jam, so that they reached St. Vith after the 7th Armored. The Germans committed their tanks piecemeal for three days, wasting the advantage of their numbers. CCB used a mobile defense, defending dominant terrain with dug-in infantry and tank destroyers, while holding its tanks as a mobile counterattacking force. Repeated US spoiling attacks kept the Germans off balance and made them believe they faced a much larger force than they did. The mobility of the M4 tank permitted the successful implementation of these tactics. /Loss ratios to be included when charts are completed./

Bastogne, 17-20 December 1944

In the area east of Bastogne, in southeastern Belgium, on the edge of the Ardennes Forest, elements of two American armored divisions, the 9th and the 10th, clashed with elements of three

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German divisions, the 2d Panzer, 26th Volksgrenadier, and 130th Panzer Lehr in a series of uncoordinated actions. The German XLVII Panzer Corps, to which the German divisions belonged, was driving westward around Bastogne toward the Meuse River, as part of their great Ardennes counteroffensive. The Americans were assigned the task of holding them back from the roads leading into the city. CCR of the 9th Armored Division and CCB of the 10th were posted at various points in task forces comprising approximately a battalion apiece, variously supported by artillery, armored infantry, and other elements. Most of the action took place in fog, smoke, or darkness, with the Germans attacking with small numbers of tanks, and generally at fairly close range since poor visibility prevented their taking advantage of their longer range guns. The greatly outnumbered Americans suffered losses in a ratio of 5 to 3, but they achieved their objective of delaying the German advance. Tanks, tank destroyers, artillery, and infantry worked together in teams to drive off repeated attacks or, to exact a high price for their own destruction. The Germans, surprised to find their way blocked, lacked the information and the leadership to coordinate their attacks and to remove quickly the obstacles which they certainly had the strength to overcome. They did ultimately get through, but not until their schedule had been disrupted and their attack thrown off balance.

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Alam Halfa, 31 August-3 September 1942

Elements of the British 7th and 10th Armored Divisions conducted a successful defense of Alam Halfa in the Egyptian Western Desert against General Erwin Rommel's Afrika Corps (15th and 21st Panzer Divisions) by using their tanks dug in, in a static defensive role. This unconventional use of armor was dictated by the qualitative inferiority of the Grant medium tanks with which the British were equipped. The Grants had 75mm. short guns (31 cal. long) with relatively low muzzle velocity, and speed not significantly higher than that of the opposing Pz.Kpfw. IIIs and IVs, which were much more heavily gunned (50mm., L/60 and 75mm., L/43 or L/48). The usefulness of the Grant gun was further severely limited by its low side mount, which permitted little adjustment of elevation or traverse. The Grants' high silhouettes also made them easy targets on the battlefield and, as the British used them, the tank commander had to partly expose himself in order to direct fire.

A breakthrough at Alam Halfa was essential to Rommel, as he could no longer support himself in Egypt unless he could break through to Alexandria and Cairo. Thus, although the numerically superior British force lost tanks in a ratio of 1.34:1, Rommel's repulse was not only a British tactical success, but also a significant strategic victory.

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An important factor in the battle was a British minefield that delayed the Germans for six hours, forcing Rommel to attack in daylight and lose the advantage of surprise, and also so depleting his limited fuel supplies that he was forced to attack frontally, rather than make the flanking sweep he had planned. British air harassment also contributed significantly to the victory.

Chouigui Pass--26 November 1942

Tank speed and maneuverability, together with a near-perfect tactical plan, were the main factors influencing the small-unit US victory at Chouigui Pass in Tunisia, the first US armor action of World War II. In overall qualitative characteristics, the German tanks outclassed the American tanks. A detachment of the German 190th Panzer Battalion, 10th Panzer Division, was fighting with 13 Mark III and Mark IV medium tanks, all of which were equipped with 50mm. and 75mm. guns. The US force--two companies of the 1st Battalion, 1st Armored Regiment, had 25 tanks, all light M3s, with 37mm. guns, 53 calibers long that were completely incapable of penetrating the German armor. The mobility of the light tanks, coupled with superior tactics, enabled the Americans to hit the German tanks in the rear, engines, and tracks, resulting in a US loss of only 28% of the tanks engaged, and a German loss of 69%. The US to German loss ratio was 1:1.29.

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Targul Frumos, May 1944

A German Panzer Division under General Hasso von Manteuffel and a Soviet tank army (or motorized army) opposed each other on a broad open plain in the Battle of Targul Frumos. Speed and maneuverability were the important factors and in these the German Mark IVs and Mark VIs surpassed the powerfully gunned Soviet JS-III. The Russians were able to surprise the Germans by opening fire with their high-velocity 120mm. gun at a range which was far beyond the effective range of the German tank guns. When the Germans were within their normal firing range their guns were unable to penetrate the heavy Soviet armor. The Germans closed the distance quickly and, due to superior mobility, maneuvered around the Russian tanks to hit their thinner side and rear armor. The result was a clear-cut German victory, achieved by superior leadership and tactical ability and facilitated by certain weaknesses in the JS-III--a slow hand traverse mechanism for a very heavy turret, a meager supply of ammunition because the rounds were so large that fewer rounds filled up more space, and heavy separate hand-loading ammunition that slowed the rate of fire. Of a total of 410 tanks the Russians lost 350 and 60 others were damaged; the Germans lost only 11 tanks out of a total of 160.

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III. ANALYSIS

A study of the armored force engagements contained in this study suggest that there are three major kinds of tank operational characteristics, and two important subsidiary characteristics, which affect the outcome of armored engagements. These five characteristics, listed in what appears to be the order of their relative importance, are as follows:

1. Tactical Mobility (Substantial speed combined with cross-country capability under any likely combat circumstances, to include if possible a slight margin of superiority over enemy tanks of comparable role and characteristics.)

2. Firepower (Ability to fire quickly, accurately, and repeatedly, with a weapon whose projectile has sufficient mass and muzzle velocity to destroy a likely opposing tank at reasonable range.)

3. Protection (Full protection against small arms, shell fragments, and long-range fire from the most likely possible armored opponent.)

4. Endurance (Ability to operate effectively over substantial periods of time and extensive distances; this is also an aspect of strategic mobility, and is enhanced by well-organized logistical support.)

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5. Reliability (Minimum of breakdowns under the combat circumstances to be expected; ease of first echelon maintenance.)

Also emerging from the experiences in this study there appear to be five major prerequisites for the effective employment of armored forces:

1. Aggressive, imaginative, skilled leadership, to exploit one's own advantages and minimize one's own weaknesses with respect to the opponent.

2. A coherent and effective doctrine for the employment of armor.

3. Effective training in the established doctrine to assure common understanding and maximum coordination capability.

4. Maximum possible combined arms coordination with available artillery, infantry, and air support, in accordance with the established doctrine.

5. Employment of tanks in mass, to the maximum extent possible under the circumstances.

From these experiences it is possible to make several general observations:

1. Numerically fewer tanks, with superior operational characteristics, are particularly effective in the defense, although this effectiveness will be seriously reduced if they do not have firepower superiority over the enemy.

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2. Numbers, in general, are more important than firepower or protection, because of the advantages superior numbers provide in maneuver and mass. Number, however, are evidently less important than mobility, unless the numerical inferiority is overwhelming.

3. In engagements of large numbers of adequate tanks, the side with the greatest mobility is usually victorious, unless it is greatly outnumbered, or unless its tanks are seriously inferior in one of the three major operational characteristics. The turning point in terms of the relationship of mobility to numbers depends on too many factors to be specified precisely, but the effects of disparity of numbers are obviously reduced by effective doctrine, adequate training, and good leadership on the side with numerical inferiority.

4. The effects of numerical inferiority of tanks are greatly minimized by the availability of supporting forces of other arms, particularly antitank weapons, artillery, infantry, and air support. These supporting weapons and units have the primary effect of enhancing the mobility of friendly tanks, and inhibiting the mobility of the opposition.

Not surprisingly, this study shows that, all other things being equal:

- a. Superior leadership is usually successful.
- b. Superior numbers usually win.
- c. Superior weapons usually defeat inferior.

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The study also suggests certain conclusions with respect to various mixes of leadership, numbers, and weapons. If all the variables and intangible factors of combat (leadership, terrain, morale, availability of supporting troops, etc.) are equal, and if the size of the forces is approximately equal, tanks with superior characteristics will ordinarily defeat an equal number of tanks with lesser characteristics. If the tanks of one side have a superiority in one or more characteristics, while those of the other side have superiority in other characteristics, the outcome of a conflict between equal numbers is much harder to predict. The results of engagements studied would suggest, however, that if the tanks on both sides meet at least minimum operational requirements for adequacy in all five operational characteristics, then the listed order of priority of the five characteristics (mobility, firepower, protection, endurance, and reliability) become particularly significant. There should be exploration of the possibility of assigning relative quantified values to these characteristics, for comparative purposes.

It is understood that the purpose of this study is to assist policymakers in deciding an allocation of available resources to obtain the maximum return for armored conflict. Thus, it is essential at the outset to determine how and why tanks can contribute to success in battle. There seem to be three major possible roles for tanks, not mutually exclusive, and not necessarily

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in order of relative importance: (1) to defeat other tanks; (2) to provide the most economical collection of protected firepower for defense; (3) to contribute to maximum overall combat capability in the maximum possible variety of combat situations.

It is undeniable that the best antitank weapon is a tank--but it is an extremely expensive weapon. The resources of men, complicated manufactured materials, and money required for production, training, and deployment could produce a number of high-velocity antitank guns, tank mines, and the highly mobile troops required to man these guns and place these mines, which would in sum be more effective in antitank defense than would the single tank they replace. Thus, if our mission is simply to defeat other tanks, the best allocation of resources might well be to antitank means other than tanks.

It is clear, however, that an enemy tank force meeting such a defense of antitank guns and mines would employ a combined arms approach in which infantry, artillery, and engineers, supported by tanks, would be employed.

To counter such a combined arms offensive against our anti-tank defenses, it would be essential to have, in addition to the purely antitank defense, adequate quantities of defending infantry and artillery, plus, probably, a small number of very powerful tanks, particularly strong in firepower and protection to work with infantry and artillery in opposing hostile attacks and to

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provide an effective counterattack force against the enemy's combined arms capability. There is reason to believe, however, from the examples we have studied, that if the attacking force can at least offset the capability of the defense in artillery, infantry, and engineers, and can mass a superior number of tanks with adequate operational characteristics (even though lacking all or most of the qualitative values of the less numerous defending tanks), this qualitative superiority of the defenders is not likely to be sufficient to assure successful defense. At the same time, even if the defense should be completely successful, there is some question whether the smaller number of very powerful tanks would be able to exploit such a defensive success as well as a larger number of somewhat less expensive tanks.

While tanks are highly effective as antitank weapons, it is clear from our studies that they are also especially effective, both as weapons and as components of a combined-arms team, in employing their mobility and shock action capability in offensive action against both unarmored and armored hostile forces. A successful defense is at least partially wasted if the defenders are not thereupon able to seize the initiative in offensive action. It is clear from the examples we have studied that a smaller number of very powerful tanks, particularly if not more mobile than the opponents', is not likely to be so successful in an attack against enemy armor as would be a larger number. Furthermore, it

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appears to have been amply demonstrated that the shock action and exploitation capabilities of tanks against unarmored forces are enhanced by numbers, probably in geometric proportion, in terms both of psychological impact and of maneuver capabilities.

It is probably impossible to come up with a formula which will express the ideal relationship between numbers of tanks and quantities of unarmored units armed with small arms as well as with heavier weapons, including artillery. In the type of relatively open terrain which favors any use of armored forces in large numbers, however, it is probable that a proportion of one armored division to each other type of division would not be too much armor. Since it is doubtful that any nation will have the resources to cover vast fronts with this high proportion of armor to infantry and other arms, the ratio could be considered as an optimum objective. It would thus appear that resources available for armor along should be so allocated as to produce maximum numbers of tanks that are adequate in the four lower priority characteristics, and that are highly mobile under all likely combat circumstances. It would appear to be a serious mistake to try to approach the optimum in all five characteristics, if this were to mean a substantially smaller number of tanks.

An important factor in the decision must be the realization that the role of armored forces cannot and should not be limited to combat with opposing armor. We have noted that nonarmored

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antitank defenses can be made far stronger than would be possible by allocating the same resources to armor for defensive purposes. More significant, however, is the demonstrated fact of two more important, and overriding roles for armor: (1) extensive, rapid, and relatively secure maneuver capability in intensive combat; (2) the psychological effect of the employment of tanks in mass against hostile unarmored forces; and (3) breakthrough and exploitation in rear areas with relative imperviousness to rear area troops and countermeasures. Thus in allocating resources the aim should be a combination of highly mobile, but otherwise merely adequate, armor in combination with effective antitank weapons, artillery, and infantry, to be employed both offensively and defensively (bearing in mind that firepower is the most important operational characteristic of armor in combined arms defense). But it should be further borne in mind that the primary role of the tank is offensive, rather than defensive, and that other, nonarmored measures are available to offset tank deficiencies in numbers and quality in the defense.

On balance, then, the effectiveness of tanks in their primary missions of maneuver and shock action is at least directly proportional to the number of "adequate" tanks available. This would seem to justify a production policy which will assure the maximum number of tanks which at least meet all five of the minimum operational requirements, and which exceed the minimum mobility requirement.

IV. EVALUATION OF ANALYTICAL FINDINGS

Limitations on Data and on Analysis

For reasons discussed earlier in this report (Section I, Methodology), it has been necessary to proceed as rapidly as possible to the analysis of as many individual tank engagements for which sufficient data was available to permit a reasonably valid analysis of armored conflict. While every possible effort was made to find actions representative of as wide a variety of tank engagements as possible, the initial approach was necessarily in the nature of a net-casting process, rather than a deliberate approach to analysis of the results of specific actions, or series of actions, as part of a planned and systematic procedure. Furthermore, lack of available data for some actions or campaigns which had been on the original list has led still further toward a collection of individual studies selected for convenience, rather than as elements of a sound, systems approach.

The engagements studied are for the most part those for which primary and secondary source material is readily available because the actions were in themselves dramatic or unusual, or were parts of larger, dramatic operations. Not unexpectedly, these are more often than not actions in which a high order of leadership, or special circumstances, resulted in victory by tank

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units that were outnumbered, or were outgunned, or that otherwise suffered under some serious disadvantage. Fortunately, there are enough of these actions, in different armies, to provide some sort of balance, but this balance is largely fortuitous. It is not clear from our data whether the actions we describe were typical, or quite atypical, or something in between. We suspect the latter, but we cannot be certain from the data that we have.

This does not in any way invalidate the data, analysis, or the findings, of any of the individual actions investigated in this study, nor--we believe--does it invalidate the overall conclusions we shall draw from review of these findings in the next section of this report. But it does mean that we cannot be certain that we have all of the conclusions which might be desirable for the purposes of this study.

What is particularly lacking from this study is an indication of the effect of sustained operations on armored conflict, and on different kinds of tanks with varying characteristics, particularly in the kind of war of rapid and long-range movement for which armor is particularly suited. In the time available for this study there was not sufficient time nor funds to undertake the painstaking collection of basic primary source data on the operations of one or more units over extended periods of time, to include all of the opposing force data essential to the analysis.

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That such data can be found seems certain, but even that for US forces is not readily available in this country, and in some instances it would be necessary to obtain access to German (and possibly British) archival materials.

As a result, we have not been able to give sufficient consideration to the operational characteristics of endurance and reliability, nor to the effects of sustained operations on leadership and on troops in their performance in armored conflict.

Systematic Approach to Remove Limitations

Four specific actions could be taken to develop a research plan which would both profit from what has been accomplished in this study, and would at the same time assure the comprehensiveness and catholicity which was not possible in this study in the time available:

1. Review each of the engagements examined in detail in this study to ascertain which ones could profit from expansion, and the availability of more data, and which ones could be related either to subsequent or to prior operations, in order to provide greater insights into the operational tank characteristics of endurance and reliability.

2. Ascertain what information is needed, and where it is likely to be available, for important armored conflict and operations experience in modern history which has not been covered

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significantly in this study; for instance: primary source data is undoubtedly available on operations in the Western Desert from 1941-1943 both in Britain and in Germany; more information on armored combat on the Eastern Front is probably available in Germany.

3. Review the various armored conflict experience analyses available (See Appendix B) to find actions or campaigns in which data was evidently available to the analysts who prepared these studies, and select all instances which offer the possibility of fruitful further investigation along the lines of this study.

4. Select two or more armored units with extensive experience in World War II, and follow these for one or more entire campaigns, detailing and analyzing all noncombat as well as combat losses, and evaluating the influence of these losses--and all other relevant influences--on the results of engagements in which these units were engaged. Ideally, at least six such unit operational surveys should be undertaken: two American armored divisions, two British armored divisions, and two German armored divisions.

Implications for Cost-Effectiveness Military Operations Research

The laboratory of the military man has traditionally been war itself; from review and analysis of the records of past combat

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It is evident, then, that further extensive research in all these records can perform two important kinds of functions. First, the records can be exploited systematically to provide the kinds of information needed to assist in important policy decisions on current military problems of procurement, design, or tactics, as in the case of this study. Second, these records can provide a basis for equally systematic verification or validation of the results of wargames.

There are a number of ways in which these records could be systematically mined and the results analyzed to accomplish these objectives. One possibility would be to establish an institute for military operational records evaluation, which might operate much as the Navy's George Washington University Logistics Research Project operates. This and other possibilities should be explored for the benefit of all of the military services, of the Department of Defense, and in particular the Office of the Assistant Secretary of Defense (Systems Analysis). Such an institute, furthermore, could provide bases for modified combat reporting systems, to remedy in the future reporting deficiencies of the past.

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Appendix C

COMMENTS ON GERMAN MILITARY DOCUMENTS

(A Report by Wlodzimierz Onacewicz)

1. Examined microfilms of German military documents at the National Archives contain a tremendous amount of unpublished information on various aspects of the German military establishment during World War II, its organization and armament, strategy and tactics, and descriptions and analyses of battles and campaigns, evaluations of the enemy, and evidence of shortcomings and difficulties experienced by the Germans in the last years of the war. This information is contained in war diaries of divisions, army corps, armies, and army groups; combat and logistic orders and reports; intelligence documents; reports on human and material losses and replacements; analyses of battle experience; and a great variety of other documents. It must be observed that because of the unsystematic way in which the microfilmed files were compiled, the search for a definite kind of information requires examination of a considerable number of unrelated documents and is an extremely time-consuming process. However, we have learned that the results of such search are often rewarding.

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2. Our recent specific search for information on German military losses, human and material, particularly for armored conflict, in most cases gave only limited results. This was due partially to limited time available for search, but mainly to the scarcity of reports on losses in the files. Our research proved beyond any doubt that in the German armed forces daily and periodical reports on human and material losses were systematically compiled by all German units and headquarters, and forwarded to the next level of command. When we found such reports (usually prepared on special printed forms), they proved excellent, detailed, complete, and apparently accurate, and were most useful to our studies. Trying to establish the cause of scarcity of losses reports, in the microfilmed files, we learned that a great number of German military files have been returned to Germany without being microfilmed, which suggests that among nonmicrofilmed and returned documents were reports on losses that, because they were so common, did not seem important to the persons who selected documents for microfilming. Thus it seems most probable that the missing reports on losses could be located in Germany.

3. Conclusion. Exploration of German military documents, as a primary source of information on the German side in World War II, is of great significance to our studies on the postwar development of various aspects of military doctrine, principles of modern combat, and combat effectiveness of modern weapons. In

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fact, it seems that no study using the experience of recent wars can be considered sufficiently comprehensive without the study of these unique documents. Although some of this material has been retained in the US National Archives, systematic research in German records requires searching the archives in Germany.

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HISTORICAL DATA ON TACTICAL AIR OPERATIONS
(Phase II)

Disruption in Combat

28 Disruption in Combat

A Report Prepared for Headquarters USAF
Assistant Chief of Staff
Studies and Analysis
General Purposes and Airlift Studies
Under Air Force Contract
No. F-44620-69-C-0084
15 February 1970

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HISTORICAL DATA ON TACTICAL AIR OPERATIONS
(Phase II)

Disruption in Combat

An Exploratory Study by
The Historical Evaluation and Research Organization

Introduction

Terms of Reference

This study on "Disruption in Combat" was undertaken by the Historical Evaluation and Research Organization (HERO) as the third of three sub-studies of Phase II of HERO's Study on "Historical Data on Tactical Air Support," performed for the Assistant Chief of Staff, Studies and Analysis, U.S. Air Force, under Air Force Contract No. F-44620-69-C-0084.

The statement of the Objective of this sub-study, as approved by the "Saber Measures" Tactical Monitor on the basis of exchanges of memoranda and discussion, was as follows:

"To explore and--to the extent time permits--analyze available literature which deals with the effect of disruption (confusion, inhibitions on communications, inhibitions on leadership control, inhibitions on movement, panic, etc., resulting from enemy actions or interference) for the purpose of finding outstanding examples of disruption in military history (particularly military history of the 20th Century); this exploration will include any theoretical

studies and analyses that may be discovered on disruption and its effects on combat leadership and on combat performance."

The work plan for this sub-study, similarly approved by the "Saber Measures" Tactical Monitor, was as follows:

"This sub-study will be performed in two major steps:

(1) bibliographical search for theoretical studies and for accounts of outstanding examples of disruption, and (2) analysis of the results of the first phase, with a view to preparing recommendations regarding the possible utility of future U.S. Air Force studies programs of a more intensive study of this subject."

HERO was directed to allocate resources of personnel labor effort to this study on a priority below that of the other two sub-studies of Phase II of the overall study. It was recognized that this inhibition on study effort might result in some imbalance in the effort to be devoted to this sub-study and, in fact, such an imbalance has resulted.

Nature of Investigation

As planned, a bibliographical search was undertaken, with generally unsatisfactory results, as noted in Section I of the Report. However, two documents studied in the performance of the first sub-studies of Phase II contained some useful information. Also, the fortuitous discovery of previously unknown and unanticipated German air Force records in the microfilmed German Army records in the U.S. National Archives was exploited, to the extent permitted by availability of time and of professional effort budgeted under the contract.

The analytical effort envisaged as the second step in the work plan for this sub-study had to be delayed until the first two sub-study reports were completed and submitted. The intensive consideration devoted to this step, in a relatively brief time, is reflected in Sections II and III of the Report.

Sources Consulted

See Bibliography

Contributors to the Report

Overall direction of this sub-study, and most of the detailed coordination and analysis were performed by T.N. Dupuy. Other contributors were Brooke Nihart, Wlodzimierz Onacewicz, Leopold B. Koziebrodzki, and Grace P. Hayes. Brigadier General Edwin S. Chickering, USAF, Ret., was also consulted in the preparation of this report. Valuable comments on early drafts were received from HERO Associates: Marshall Andrews, Richard Leighton, and Theodore Ropp. Mr. Andrews' extensive, and particularly helpful, comments were based upon his own personal research in this area, and contributed greatly to the analysis.

As the principal author of this report, and as Executive Director of HERO, the undersigned assumes full responsibility for the report and its contents.

T.N. Dupuy

Dunn Loring, Virginia
15 February 1970

I. The Literature of Disruption

Underlying Assumptions

The underlying assumptions which have led to this exploration of "Disruption in Combat" would suggest that the subject is potentially so important to an understanding of success in battle and success in war that there should be a significant literature on the subject. It is therefore somewhat disappointing to report that no such literature appears to exist. Even more disappointing, and leading to a need to question seriously the validity of the assumptions, is that there does not even appear to be any substantial expression of theoretical opinion that there is a requirement for such a literature.

This state of affairs having been noted at an early stage in the exploration, the assumptions were re-examined, and still seemed to the investigators to warrant a continuation of the study, if only to ascertain the reason for the apparent contradiction. The results of this reexamination are shown later in this report. At this point it is only necessary to present the assumptions, and to expose the state of the literature.

The basic, underlying, assumptions are:

1. Disruption is a general state of impaired combat effectiveness in a military force resulting from some circumstances or conditions (usually, but not necessarily, the direct result of hostile action) inhibiting the planned, or programmed, or anticipated operational capabilities of one or more of the component elements of the

military force; the principal manifestations of disruption are: confusion, reduced communications capability, reduced leadership control, reduced movement capability, panic, and the like.

2. A basic objective of war and warmaking is to break the enemy's will and capability to resist; among the major means of accomplishing this is the disruption (as contrasted with destruction) of enemy operational capabilities.

3. Since, more often than not, the ability of a military force to operate effectively disappears before the physical elimination of its means or resources for combat capability, disruption has presumably been largely responsible for the disappearance of operational capability.

4. If it can be shown that one or more forms of disruption has affected the operational capability of a military force, analysis of the operations which led to this should reveal the qualitative impact of disruption on military forces, and should also suggest the quantitative effect of disruptive measures.

Disruption in Theoretical Literature

Some of the classic military theoreticians of the 18th and 19th Centuries noted the existence of disruption in warfare, and commented on it in varying ways as follows:

Frederick the Great: Everything which the enemy least expects will succeed the best. . . . [And in another passage:] When a general conducts himself with all prudence, he can still suffer ill fortune; for how many things do not cooperate at all with his labors! Weather, harvest, the officers, the health or sickness of his troops, blunders,

the death of an officer on whom he counts, discouragement of the troops, exposure of your spies, negligence of the officers who should reconnoiter the enemy, and finally, betrayal.

Napoleon: War is composed of nothing but accidents and, although holding to general principles, a general should never lose sight of everything to enable him to profit from these accidents; that is the mark of genius. In war there is but one favorable moment; the great art is to seize it.

Clausewitz: "Everything is simple in war, but the simplest thing is difficult. . . . So in war, through the influence of innumerable trifling circumstances, which on paper cannot properly be taken into consideration, everything depresses us and we come far short of our mark. . . . Friction is the only conception which in a fairly general way corresponds to that which distinguishes real war from war on paper. . . . This enormous friction . . . is . . . everywhere brought into contact with chance, and thus produces incidents quite impossible to foresee.

Dennis Hart Mahan: In the presence of an enemy who, having lost his communications, is entirely disorganized and demoralized . . . we have only to throw our forces into the midst of those broken-up fractions to determine them to fly. We may here attempt any blow; no movements can fail to turn out well except those which are too slow and methodical.

There was neither time nor opportunity for a thorough review of the theoretical writings of these or other respected military theorists, but a general survey of theoretical military literature

makes it appear safe to say that neither these authorities nor other respected military theorists, have devoted any comprehensive effort to a consideration either of the nature or causes of disruption, or to an assessment of its role or significance in warfare.

Perhaps even more surprising is the apparent lack of concern for disruption as a topic for research in the proliferating literature of research since World War II. While there are a number of studies in certain, narrow aspects of disruption, or on some of the rather specific results of disruption, there seems again to be absolutely nothing dealing with the topic as a comprehensive subject for research.

It was hoped that some of the behavioral scholars, in their analyses of human behavior in circumstances of stress or confusion, would have given at least some consideration to human behavior in disruptive situations in combat. We have made no effort to explore, or even to survey, this field of research, but three eminent behavioral scholars have informed us that they do not believe that there is anything directly pertinent in the literature of their field. They have, however, suggested that some literature on disaster might be useful; there has not been time to explore this.

Disruption in Operational Literature

In both primary and secondary source materials dealing with military operations the researcher can find massive documented evidence of disruption in combat. However, nowhere in the relatively limited samples which we have examined in this vast area of literature have we found any effort by historians or operations analysts either to deal analytically with a number of examples of disruption,

or to attempt any kind of comprehensive analysis of a single disruptive event or series of events.

Because this study is being performed for the US Air Force, and because of the obvious effectiveness of airpower as a disruptive force in combat, we gave particular attention to operational literature on the application of airpower for disruptive purposes. The general lack of analytical content in the literature has been noted above. However, there are some useful discussions of instances of disruption caused by both German and Allied airpower in World War II, and some of these will be considered in a subsequent section of this report.

A particularly determined effort was made to find documentation of disruption created by the Luftwaffe in some of its earlier campaigns in World War II, both in American and German records. However, by intensive screening of microfilmed German Army records in the US National Archives, some useful information was obtained--though it may be questioned whether the results, at least for this study, were worth the effort. (An incidental benefit from this exploration, however, was confirmation that, in the light of the sad state of the German Air Force Records for World War II in the German Military Archives, probably the best and most complete source of reliable documentation of World War II German air operations is the German Army records.)

II. Disruption in Military History

General

In the performance of this study attention has been focussed primarily (but not entirely) upon German and Allied use of airpower for disruptive purposes in World War II. Some consideration has been given, however, to the immediate and general contexts within which these primarily air operations must be considered. This led us to survey not only the interrelationship of air and ground operations in terms of disruptive influences in World War II, but also examples of disruption in earlier military history.

The general historical survey confirms the prevalence of disruption--both accidental and resulting from conscious effort--in military operations since the dawn of history. A significant proportion of historical victories in battles, campaigns, and wars have resulted from the collapse, or reduced effectiveness, of one side before its military forces were physically overpowered or overwhelmed by the victor. In all such instances, we assume that the defeated forces have been the victims of disruption.

Military and political leaders have always been more or less aware of the bonus benefits to be derived from actions (particularly unexpected actions) that struck or threatened vulnerable people, facilities, or activities which were--or should have been--shielded by the hard fighting face of a military force. This realization led to the military concepts of ambush, envelopment, raid, and partisan or guerrilla warfare, all of which were directed at what the British call "the tail of an army," and all of which were demonstrated

effectively in combat even before the time of Alexander the Great.

It is also evident that disruption has historically not been necessarily the result of hostile threats or action alone. For instance, the outcomes of battles like Crecy and Waterloo were significantly affected by pre-battle rainstorms which inhibited troop movements; one engagement in East Africa in World War I was influenced by a swarm of bees; and US air operations in Italy in World War II were disrupted by an eruption of Mount Vesuvius. Similarly, disruption within a military force can be created by actions--or inaction--of individuals or groups within that force, resulting from incompetence, oversight, misunderstanding, or even treachery. Obviously, as in the case of treachery, the opposing force can often enhance the effects of internally-generated disruption, or disruption from natural causes, either through deliberate preparations, or by alert seizure of an unexpected opportunity.

Aircraft have, from their earliest appearance in warfare, been particularly useful as instruments of disruption. This is due partly to the fact that the essential characteristics of aircraft enable them to avoid a direct confrontation with "the hard fighting face" of the enemy by flying over it and moving directly against the more vulnerable and sensitive rear areas, and partly to the psychological effect of attack from the air upon fighting men on the ground. Thus, by literally adding a new dimension to warfare, it would appear that airpower has increased the potential significance of disruption in warfare.

In a very general survey of military history we have noted a number of specific actions which demonstrate the influence of

disruption on combat. It is beyond the scope of this study to attempt a detailed analysis of any of these. They are listed below, with a few brief comments for each, not only in response to the statement of the Objective of this study, but also to suggest how detailed analysis could contribute to future research, leading to improved understanding and utilization of the concept of disruption. We have selected only a few, random examples of the pre-airpower era, and of the brief transitional era from 1914 through 1938, and have concentrated attention on examples of disruption in World War II and since.

Pre-Airpower Examples of Disruption

Byzantine Warfare. Byzantine theories of warfare laid great stress upon the employment of all possible means to weaken an enemy before battle, and when battle was joined to strike at the most vulnerable elements of hostile forces. The use of bribes to stimulate and to encourage subversion and treachery, employment of detached forces for raid and ambush, and emphasis on enveloping maneuver in combat operations, are examples of how the Byzantines consciously attempted to bring about the collapse of their enemies without the necessity for physically overpowering them in costly frontal engagements.

The Seventh Crusade. The invasion of Egypt by forces under Louis IX of France presents some easily discernable examples of disruption from both natural and internal causes.

Mongol Disruptive Concepts. The Mongols, who were almost invariably greatly outnumbered by their enemies, were particularly

adept at the use of disruption through subversion, terror, and (particularly) both strategic and tactical maneuver.

The Battle of Germantown. This small operation is replete with diverse examples of disruption caused by hostile action, from internal causes, and from natural causes. It could, perhaps, be the classic case study of disruption.

Napoleonic Disruptive Concepts. Although Napoleon had no realization of the fact, the considerations that led him to develop his unique system of warfare were strikingly similar to those which led Genghis Khan to develop the Mongol system of warfare. It was Napoleon's strategic aim--frequently achieved, as at Marengo, Ulm, and Jena--to win a campaign before the first shot was fired. This was accomplished through various forms of disruption, with maneuver the primary operational technique.

The Crimean War. Few wars have been marked by so much disruption caused by incompetence as was evidenced on both sides in this war.

The American Civil War. An important consideration in this war was the ability of the Southern people and Southern leaders to endure the considerable disruption caused by the Union blockade, and to continue the war until their military forces were indeed physically overwhelmed. While there was considerable disruption evident among forces on both sides on a number of occasions, only a few of these had strategic significance, as Grant's disruptive strategy in the Vicksburg Campaign, and the disruption achieved by Sherman's marches in Georgia and the Carolinas.

Disruption in the Transitional Era.

World War I. There is perhaps no more dramatic example of disruption than the collapse of Germany in 1918, while the German armies in the field were still essentially intact and undefeated. Any intensive study of disruption in modern war should include consideration of this phenomenon, and the role of Ludendorff in the collapse and in the events leading up to it. Other aspects of World War I which warrant further study in relation to disruption are:

a. The role of airpower (particularly in the Balkans and in Palestine), and the apparent lack of realization at that time, and in the interwar years, of the disruptive capabilities of airpower in support of ground combat;

b. Chemical warfare and disruption;

c. Examples of disruption in battle, particularly:

(1) Tannenberg

(2) The Marne

(3) Gallipoli

(4) Nivelle Offensive

(5) Caporetto

(6) The German Somme Offensive

(7) Megiddo

Italo-Ethiopian War. The disruptive value of airpower was very clearly demonstrated here, and is particularly noticeable in comparison with the last previous Italo-Ethiopian conflict, some forty years earlier, which had culminated in Italian defeat at Adowa.

Spanish Civil War. There are numerous examples of disruption, affecting both sides. Again the growing disruptive importance of

airpower is noticeable. Perhaps equally significant is the evidence that the Loyalist collapse, while perhaps inevitable, came suddenly as the result of disintegration due to disruptive influence.

World War II

As noted above, this was the focus of research leading to the preparation of this study. Examples below marked by an asterisk (*) were explored in more detail than the others; sources are shown in the Bibliography.

German Disruptive Efforts. Among the more important examples of disruption caused by, or exploited by, the Germans, are the following:

* Battle of Poland, 1939. Despite the fragmentary nature of Luftwaffe records, there is sufficient documentary material available in the German Army World War II microfilmed records in the US National Archives to permit intensive study of the manner in which the Germans used airpower to cause disruption in Poland and the Polish armed forces. Particularly worthy of separate study are the interdiction campaign of the German Air Force against Polish military installations and facilities, and the bombardment of Warsaw in the closing days of the campaign. (For German terror bombing, see below.)

* Terror Bombing as a Disruptive Force. Deliberate terror bombing was done by the Luftwaffe in Poland, in the Low Countries, in the Battle of France, and in operations against Britain. The reasons for success in some instances, and failure in

others, should be determined by comparative analysis.

- * Norway, 1940. German use of airpower for disruptive effect, particularly in the Namsos-Andalsees operations, warrants further study.
- * Battle of Flanders, 1940. The disruptive aspects of blitzkrieg were most dramatically revealed in this campaign. Particularly noteworthy are the success of air strikes combined with airborne drops at Fort Eben Emael and elsewhere; also the successful interdiction campaign, the destruction of the Allied air forces in the first four days of combat, and the role of the Luftwaffe in the Meuse crossings and at Dunkirk warrant study. The German use of terror bombing is noted elsewhere (see above).
- * Battle of France, 1940. With one exception, the principal disruptive aspects of this campaign could be considered together with those of the Battle of Flanders, noted above. That one significant exception is the collapse of the French Army, which has been almost exhaustively analyzed--but never in terms of disruption in combat.

Battle of Crete, 1941. This is one of the few operations in history in which it can be demonstrated that airpower was the single, vital determinant of victory. The disruptive use of that airpower should be given separate attention.

Operations in Tunisia, 1942-1943. This was one of the last campaigns in the war in which German airpower was employed to achieve significant disruptive successes. Particularly notable were the German use of airpower in the halting of the initial Allied drive into Tunisia, and Rommel's use of combined arms

in his success at Kassarine Pass.

- * Ardennes Offensive, December 1944. This is an interesting example of use of weather to avoid hostile disruption, and of the success and failure of a number of other disruptive efforts. Despite the extensive bibliography that exists on this, it warrants another review from the standpoint of disruption. The existing studies can facilitate this review.

Allied Disruptive Efforts in Europe-North Africa

British "Dirty Tricks." The British effort to strike back at the German occupiers of Western Europe after Dunkirk should be studied for its disruptive aspects, both in concept and in results. Access to British records should be attempted through British military channels.

Dieppe Raid, August 1942. Allied efforts to disrupt the German defenders were largely unsuccessful. The Germans were more successful in disrupting the attackers.

- * Allied Interdiction of Axis Mediterranean Communications, 1940-1943. The Allied air and sea interdiction campaign against the Axis sea line of communications was essentially a disruptive effort, and was perhaps the most important single element in Rommel's eventual defeat in North Africa.

- * Bombardment of Pantelleria, May-June, 1943. The account of this operation in the World War II memoirs of Marshal of the Royal Air Force Lord Tedder provides a useful preliminary to a separate study. Tedder also refers to a contemporary study of the operations by Sir Solly Zuckerman, which may make a most useful contribution to any modern study of the topic of

disruption. Presumably access to that study can be obtained through British military channels.

* Bombardment of Monte Cassino Abbey, 15 Feb., 1944. This, perhaps the most ill-conceived air bombardment of World War II, was not only a complete failure, it was counterproductive, and was more disruptive to the Allies than to the Germans.

* Bombardment of Cassino, 15 March 1944. This disruptive effort, which also failed, warrants study not so much as an illustrative example of a failure (although there were some serious mistakes); it is noteworthy as an instance where exceptional combat capabilities of a small unit (the German defending battalion) influenced the outcome of a major engagement.

Operation "Strangle," March-May 1944. While not studied independently by HERO in the preparation of this report, the significance of the results of "Strangle" in facilitating subsequent Operation "Diadem," and the Rome Campaign, were particularly noticed in a recent HERO study. In fact, it was the desire to evaluate these results more precisely that led directly to this study.

* Operation "Diadem," May-June 1944. Few campaigns in history are so revealing of both the value and limitation of disruption. For purposes of analyzing disruption, two entirely separate studies are warranted. The first would focus on the Allied air strike of 12 May 1944, against the command and communications facilities of the German Tenth Army. (See Appendix A of HERO Study Report: "Ground Operations and Tactical Air Support for Operation 'Diadem', or the Rome Campaign,"

Phase II of the study: "Historical Data on Tactical Air Operations.") The second of these two studies would be concerned with the effects of disruption on the German forces during the remainder of the Rome Campaign, and particularly on their amazing ability to survive this disruption. (See Appendix A, herewith, a brief summation of this subject, prepared by Col. Wlodzimierz Onacewicz.)

The French Resistance. This was an essentially disruptive partisan activity. It should be restudied in this context.

* Pre-D-Day Isolation of Normandy, 1944. The disruptive effects of the isolation of Normandy are discussed tangentially in two HERO reports prepared for the study: "Historical Data on Tactical Air Operations," one dated 9 April 1969 on the Rommel-Rundstedt controversy, and another dated 28 October 1969 on German Evaluation of Allied air interdiction. This subject, however, warrants further study from the standpoint of disruption.

* Operation "Overlord," June 1944. The same comments apply to this example as to the previous one.

* Bombardments of Caen, July-August, 1944. These bombardments failed for reasons similar to the failures at Cassino. They are particularly instructive when compared with a success further west in Normandy, at St. Lo (see below).

* Carpet Bombing of St. Lo, 24-27 July 1944. This was perhaps the one instance in World War II when the shock-disruptive effects of massive air bombardments were adequately exploited by the Allies. It would unquestionably be useful to explore the

records of those units of the US VII Corps that suffered serious losses from bombs dropped short of the target area, to ascertain whether they were disrupted to a degree at all comparable to the Germans in the target area.

* Operation Market Garden, September 1944. Particularly noteworthy, within the disruption context, was the failure of the Allied air interdiction campaign to include the routes by which the Germans were able to reinforce Arnhem; a relatively small air effort might have had a considerable disruptive effect and might have prevented the defeat of the Allied airborne units.

* Operation "Queen," November 1944. This effort to improve on the carpet bombing techniques at St. Lo was a failure, and it is another example of a failure to take advantage of the disruptive potentialities of air power.

Battle of Schmidt, November 1944. This was an Allied offensive which failed, largely due to accidental disruption, as well as disruptive German efforts.

Disruption in Asia and the Pacific in World War II

Little attempt has been made in this study to undertake a review of pertinent literature on World War II in Asia and the Pacific. However, there are several examples which are obviously worth exploring further:

Chinese Disruption Against Japan, 1937-1945. This subject contains many examples of disruption, such as: diversion of the Yellow River; the "scorched earth" policy; partisan operations in Occupied China; the study should consider both success

and failure of Chinese disruptive measures and Japanese counter-measures. An extensive bibliography is available in an earlier HERO study: "Military, Political, and Psychological Implications of Massive Population Casualties in History." 17 September 1965.

Chinese Communist "100 Regiments Offensive," August-November 1940.

Perhaps more important than the moderate success of the disruptive efforts of the only Chinese Communist offensive in World War II was the Japanese reaction and its effect on the Chinese Communists.

Guerrilla Operations in the Philippines, 1942-1945. As in the topics noted above, the nature and results of the Japanese reaction is almost as important as the disruptive efforts of the guerrillas.

The Chindit Raids in Burma, 1943, 1944. The first of these raids was largely morale-building in purpose, and (except for the survivors of the badly-battered units which participated) was largely successful in this respect, due to adroit publicity. The second raid was much larger, more serious, and was essentially disruptive in its purpose. It was a major failure, despite some minor, incidental successes. Air-power was misemployed; ground combat resources were squandered, and the Japanese felt little disruptive effect.

Post-World War II

No effort has been made in this study to survey specific disruptive efforts of any of the participants in the major conflicts since

World War II. It is clear from popular accounts of these that efforts at disruption--with employment of airpower and use of partisan warfare both playing important roles--were perhaps more prevalent than even in earlier eras. At least the following seven conflicts (or groups of conflicts) should be studied for the purpose of identifying disruptive efforts, and assessing their effects.

Chinese Civil War

Vietnam War for Independence

Malayan Emergency

Arab-Israeli Wars

Korean War

Algerian Civil War

Vietnam War

III. Analysis

Disruption as a Topic for Research

The lack of a topical literature on the subject of disruption led the investigators to re-examine their basic assumptions, and particularly the definition of disruption, early in the study.* To some it seemed that the distinction which was being made between disruption and destruction was an artificial one. Although the distinction between activities that destroy hostile forces and those that disrupt hostile capabilities was recognized, it was suggested that these blend into each other to a much greater degree than the assumption would admit. This line of argument was expressed by one member of the HERO Associate Staff as follows:

It seems to me that there is a conceptual hang-up here in the effort to distinguish sharply between disruption and destruction of enemy combat capabilities. The one blends into the other. Basically, all forms of attack on an enemy military force are aimed at weakening its capabilities, and even "inhibitions" on communications, leadership control, movement, etc., fall within this category. To destroy a supply dump, or a reconnaissance unit, or a communications center, or a headquarters, or (by assassination or commando action) a commander and his key staff members -- all serve to "disrupt" the enemy's capabilities, and I can discern no point on the scale at which "disruption" clearly becomes "destruction."

The effort to make this distinction encounters the same kind of difficulty as does the distinction between action aimed at destruction of enemy forces and capabilities per se and action aimed at weakening and paralyzing the will and coordinating powers of the enemy's commanders. The same kind of action may serve both purposes. However, this distinction (one of the key concepts in Clausewitz' On War, it will be recalled) is, in my

*One Staff reviewer recommended the deletion of the following discussion on the grounds that this was merely setting up a "strawman" and then demolishing it. Since, however, this reflects the trend of a serious debate on the validity of the assumptions, it is believed that the nature of the doubts, as well as the resolution of the doubts, should be presented in some detail.

opinion, more valid -- that is, it can be more readily applied to concrete military action. It is possible to select types of action which are better calculated than other types to confuse, inhibit, or paralyze an enemy commander -- perhaps a commando attack on his headquarters, or a sniper's shot which kills his chief of staff standing beside him -- even though the material or human loss inflicted is less. This kind of distinction is close to the one proposed in this paper, but not, I think identical.

For this purpose, I should think the kinds of action one should look for, in historical precedent, are sabotage, propaganda and spreading of false rumors, demonstrations of various kinds designed for psychological impact, interference with communications and supply, subversion, assassination, and the whole gamut of covert operations other than intelligence gathering. In all these areas, it seems to me, there is a continuum from mere interference and disruption to actual destruction of capabilities -- but I suppose, for purposes of this study, one can simply draw a line arbitrarily.

Examples: 1) German infiltration of saboteurs and commandos before and during the Ardennes offensive. 2) U.S. electronic interference with North Vietnamese communications and radar by means of destroyer patrols in Gulf of Tonkin in 1964, and subsequent "spy ship" operations off North Korea and elsewhere. 3) Special Service Forces operations with Montagnard patrols against infiltration routes in Laos. 4) Current Israeli "sonic boom" attacks on Cairo and Damascus, and other recent disruptive activity; similarly, fedayeen attacks into Israel; 5) Viet Cong terrorism against South Vietnamese local officials and school teachers. 6) The German Government's facilitation of Lenin's return to Russia in 1917. 7) U.S.-Chinat commando operations against mainland China in the 1950s.

I should think that the literature on espionage and covert operations, would show some examples of what is being sought. What about the literature on pre-20th century examples of disruption, including the Bible? -- e.g., infiltration of saboteurs, spies, and assassins into the enemy camp before a battle?

After careful consideration of this thoughtful criticism of the concept of disruption as a valid, discrete subject for study, we have decided to reject the criticism and to continue with the exploration originally intended, using the original assumptions. The principal reasons for this decision are as follows:

a. We believe that the Clausewitzian distinction noted above is essentially included within the disruption concept that we have postulated;

b. The rather specialized kinds of operations that are intended primarily for psychological impact are also certainly included within the postulated disruption concept.

c. There appears to be a real need to ascertain how it is that some actions intended primarily for destructive purposes may, under some circumstances, have a significant psychological impact and, under other apparently similar circumstances, not have such an impact.

d. There also appears to be a real need to ascertain how it is that certain actions designed for limited destructive purposes may have widespread physical effects (rather than, or in addition to, psychological effects) on the combat capability of a military force, and to ascertain how, and to what extent, the physical and psychological effects are interrelated.

e. There appears to be a real conceptual discontinuity between destruction and disruption, rather than the continuum that was suggested in the quotation above; if there is a continuum, it would seem to be in the level of violence, with the low-level activities being often more disruptive in objective than is the case of those involving a high level of violence, in which disruption is only incidental to destruction.

This reconsideration of the assumptions of the study has led us to continue the investigation on these premises. It seems important, however, to redefine the conceptual nature of the distinction between destruction and disruption, as follows:

Destruction is specific and easily measured; it is generally

accomplished deliberately. Disruption is not so readily identifiable within specific parameters, and it is not easy to measure, probably because it is often fleeting; rather than being accomplished deliberately it is often fortuitous and quite incidental to the course of the battle. Or, in other terms, destruction is essentially quantitative, disruption is essentially qualitative. In still other terms, which may have considerable significance, disruption appears to be the result of influences or actions which affect the qualitative variables of combat, particularly:

training (and/or experience)

leadership

morale (which in turn is made up of the presence or absence of such human qualities as fear, fatigue, and discouragement)

environmental factors (such as terrain, weather, and local civilian attitudes)

The Scope and Nature of Disruption

Once having reached the conclusion that disruption is, indeed, a suitable subject for further research, we have found that there can be differences of opinion as to the scope of disruption, and how it should be categorized. For instance, there is some difference of opinion as to whether or not the disruption created by the shock and confusion of a sudden, violent, and unanticipated action is really comparable as a phenomenon to the disruption caused more slowly by the attrition and frustrations of an interdiction campaign or a blockade.

Since the term "disruption" seems to be as applicable to the one example as to the other, we have assumed for the purposes of this study that these two forms of disruption are really related to each other, and that they are subject to comparable forms of analysis. However, in view of the doubts expressed, it is clear that this assumption should be explored more thoroughly than was possible within the time available for this study.

Related to questions regarding the scope of disruption, are others regarding its nature under differing circumstances. We have suggested earlier that disruption, in comparison to destruction, is fleeting. Does this mean that there is no effective disruption if hostile advantage is not taken of action which is potentially disruptive? Does this further mean that exploitation is an essential component of disruption? These, too, are questions which can be resolved only through exhaustive analysis of examples of actual and potential disruption.

Disruption and Qualitative Variables in War

The questions which have been raised above with respect to the suitability of disruption as a subject for research, and with respect to the scope and nature of disruption help to explain the absence of literature dealing with this apparently important subject. The reason for this lack is simply that neither classical theorists nor modern operations analysts have been able to deal effectively with moral factors or other qualitative variables in war. They recognize the existence of the factors in imprecise and hortatory terms, then ignore them analytically, because up to this time the variables have defied

analysis. Yet it is obvious from our investigation that understanding of the subject of disruption would be greatly facilitated if we had the ability to assess the specific effects of these qualitative variables on the outcome of conflict. In other words, disruption results whenever one or more of the qualitative variables influencing the operations of a military force deviate, or are displaced, in a negative or unfavorable fashion from accepted or acceptable norms. This formulation is consistent with the concepts quoted from classical theoretical literature earlier in this report.

If this assessment of the nature of disruption, and its relationship to the qualitative variables of war, is correct, it suggests that there may be, after all, ways of coping with the thus-far imponderable problems of the qualitative factors in war, and harnessing them for both planning and disruptive purposes. There is little likelihood that it will ever be possible to express these variables in precise, quantitative terms. On the other hand, analysis of their influences in a number of military operations should rather easily permit the establishment of quantitative parameters for their ranges of influence, and to express norms for the effects of each in specific quantitative terms. This will not only permit the realistic injection of these variables into simulations, it will also permit their manipulation for planning purposes. This should facilitate more effective use of disruption in future military operations, and also permit planning to avoid, or mitigate, the results of possible hostile or accidental disruptive influences on our own forces.

A Research Program On Disruption

Time and funds available for this study do not permit us to go further into this broad area of research. What has been discovered in the course of this study, combined with previous investigations by HERO in related areas, demonstrates that abundant material exists to provide the data required for a research program to undertake effective and worthwhile exploration of the hitherto neglected field of disruption in combat.

The most logical and systematic approach for such a research program would be to remedy the present inadequacies of theoretical literature on disruption by detailed analyses of a substantial number of historical examples of disruption, thus obtaining a more thorough understanding of the phenomenon, and its relationship to the destructive objectives of war. Such analyses, among other things, would help us to determine the various categories of disruption; the causes of disruption; and the nature, extent, and effectiveness of disruptive agents or techniques. However, if a research program on disruption is to obtain the long-term support that it obviously would require, it must be evident that at an early stage in the program there will be useful results, or an opportunity will be presented to evaluate the likelihood that there will be useful results commensurate with the investment. Consequently, rather than starting with such analyses, because of the potential importance that improved understanding of qualitative variables can have in so many aspects of military planning, it is proposed that the first phase of the proposed research program focus on the relationship of disruption to these qualitative

variables and seek to produce tentative quantitative values, or ranges of values, for these variables. Such a study--like most of those envisaged for this program--would require a cooperative, interdisciplinary effort of historians, mathematicians, military specialists, and operations analysts.

In subsequent phases of the program, a data base can be gradually and systematically developed that would, in due course, provide more statistically reliable insight regarding disruption, and which would at the same time permit refinement of the quantifications of the qualitative variables. An incidental, but very important, derivative benefit would be the value which such a data base could have for planners and operations analysts in the many other fields of research which can profit from the data of actual combat experience.

For the reasons pointed out above, the Research Program presented in Appendix B provides outline research plans for the first two studies suggested for the program. For other studies merely a title and a generalized statement of the objective are indicated.

IV. Conclusions and Recommendations

Conclusions

1. Disruption, as defined in this study (~~see p. 4~~), and as distinct from destruction, has been a major determinant of the outcome of armed conflict.

2. There has been inadequate study of the nature of disruption, and the manner in which it has influenced the outcome of combat.

3. There is abundant narrative material describing disruption in combat, but apparently none has been studied specifically for the element of disruption to ascertain its scope and nature.

4. Disruption results from unanticipated effects of qualitative variables (particularly moral factors) on military operations, and to date qualitative variables have defied analysis by classical military theorists and modern operations analysts.

5. Disruption can be better understood, and its effects employed more effectively, by determining the ranges of possible influences of qualitative variables on the outcome of combat, and establishing quantitative parameters for these ranges.

6. The establishment of quantitative parameters for the operation of qualitative variables will permit the introduction of disruption, and its effects, into simulations and wargaming, not only enhancing their realism, and thus their validity, but also facilitating improved planning for the use of disruption for military purposes.

7. Secondary sources, buttressed as necessary by research in original records, provide ample data for research on the causes,

nature, and extent of disruption, and on the effectiveness of the disruptive agent, thus facilitating establishment of quantitative parameters for the related qualitative variables.

Recommendations

1. Systematic exploration of the nature of disruption and its military effects should be initiated, and a long-range research program established.

2. The first step in such an exploration would be a careful study and analysis of selected historical examples of disruption in combat in order to establish the relationship of the qualitative variables of war to disruption, and to attempt to express norms for the effects of each such variable in specific quantitative terms.

3. Further explorations within the research program should be along the lines presented in Appendix B to this report.

Appendix A

DISRUPTION*

Of the German Defensive System in Italy
by Allied Air Forces, May-June 1944

Disruption of Command

1. The German Command normally directed battle operations by means of a well developed telephone network. Unit reports, orders of headquarters at all levels, exchange of evaluations of the situation, etc., were communicated immediately by telephone, and later confirmed in writing.
2. Thus disruption of this telephone network of the German Tenth Army by intensive and continuous Allied air bombardment, beginning early on 12 May, greatly hindered, and at times paralyzed, the direction of the battle, especially at the Army and Army Group levels. In this emergency orders were despatched from the Army Headquarters by officer couriers in automobiles, but this communication was extremely slow because of jammed and blocked roads. The Commander of the Tenth Army personally traveled to the corps command posts in order to learn the situation at the front and to give orders on the spot. Radio remained available, but it seems that it could not replace the telephone.
3. Direct Allied attacks on top headquarters and command posts interfered seriously with command operations. thus, on 12 May the whole operational division of the Tenth Army headquarters was destroyed by air bombardment (8 killed, 34 wounded, houses and documents destroyed). Simultaneously almost all divisional command posts were attacked.

*A paper prepared for this study by Col. Wlodzimierz Onacewicz, Ph.D., former Polish Army, October 1969.

Disruption of Supply

1. Continuous air bombardment and destruction of defiles, road junctions, bridges and towns by bomber formations caused closing of main routes of supply. Repairing destructions was extremely difficult because of repeated Allied air attacks; mobilized Italian workers fled to the mountains. Construction of detours in the mountains was often impossible.
2. Continuous bombardment and strafing of road traffic by Allied fighter-bombers completely stopped traffic during daylight, and caused solid traffic jams during the night.
3. This systematic destruction of the road network soon disrupted the supply system and caused shortages of ammunition and fuel, which weakened the defensive capability of German troops. It also seriously interfered with the maneuver of troops. The main difficulty consisted in transportation of supplies from army depots to the front units.
4. Shortage of fuel limited the mobility of the motorized German Army. Thus the complete lack of fuel in the Tenth Army on 12 and 13 June precluded any tactical move, made it impossible to carry out the planned shift of the 15th Panzer Grenadier Division to the threatened right wing of the Army, made farther retreat of the Army impossible, and forced the entire Army to halt its retreat at a time when its existence was threatened. The fuel situation did not improve until June 16 when the retreat was resumed.
5. The supply situation was further worsened because of great losses in motor vehicles from Allied air bombardment.

Disruption of Mobility

1. Very soon daylight tactical troop moves behind the front became impossible except on rainy days. The moves were limited to night time and were extremely slow because of jams caused by supply columns in both directions. Even by night the roads were not safe from enemy fighter-bombers.
2. Tactical moves by rail further to the rear were also hindered by the Allied air forces. Thus two massive bomber attacks on Avezzano, on 22 and 23 May, each by more than 200 bombers, delayed the shift of German divisions by rail from the left to the threatened right wing of the Tenth Army.
3. There was a slowdown of the German withdrawals because of losses in motor vehicles from air attacks.
4. Early in June, the difficulty of shifting troops parallel to the front became so critical that the Army issued a drastic order to destroy all material which was not necessary to combat, and to throw off the roads all vehicles, even heavy trucks, which did not belong to fighting troops. The order contributed to the further breakdown of the supply system (though it was not strictly enforced everywhere).
5. The battlefield mobility of troops was also diminished, and bringing up of reserves for immediate counterattack became impossible because of fighter bombers, and particularly Allied artillery directed by observation planes. Mobility of German artillery was reduced by losses in motor vehicles and horses; AA batteries were especially helpless. German guns often had to be blown up because it was impossible to withdraw them.

Conclusion

1. The Allied air forces enjoyed complete domination of the air, and achieved highly effective disruption of the German command at all levels, including its supply system and its defensive system on the battlefield, at the same time inflicting severe personnel and material losses. Nevertheless, the Allies did not succeed in achieving a great strategic victory, or a decisive breakthrough of the Italian front. They were only able to push the German front slowly before them, and this at the cost of heavy losses.

2. German defensive tactics consisted first in stubborn defense of consecutive positions in mountainous terrain. Later, when their combat strength began to decline rapidly and they were threatened with a deep Allied breakthrough or envelopment, the Germans began a slow nighttime withdrawal, covered by strong rearguards fighting delaying actions. They carried out a thorough destruction of all roads, bridges, and defiles, and prepared mine barriers and other obstacles in the areas they were abandoning, which slowed down the Allied pursuit to a cautious advance.

3. Thus, although deprived almost from the beginning of the battle of close air support, and after May 30 without any direct support of the German Air Force, the German armies successfully accomplished their defense mission. They did it, however, at a tremendous cost in human lives, while whole divisions melted away during this battle, and others were reduced to a few hundred men.

Appendix B

A RESEARCH PROGRAM ON DISRUPTION

A. Disruption; Quantification of the Qualitative Variables

1. Development of hypotheses for quantification of the variables.
(An analysis of the nature of each variable, and its components; then interrelationships among variables and among components would be ascertained.)
2. Literature search for relevant data. (Review of past studies by CORG, HERO, PRC, RAC, WSEG, etc.)
3. Establishment of criteria for quantification. (How to use the statistical data found in Step 2 for the purposes of the study.)
4. Refinement of the criteria. (This would be by application of the criteria established in Step 3 to the examples found in Step 2.)
5. Detailed case study analysis of three historical examples of disruption. (These would be new examples, not to be found in Step 2, and possibly selected from the list in Part II of this study.)
6. Comparative analysis of the case studies. (Each of the case studies would be compared analytically with the other two, and with the examples of Step 2.)
7. Conclusions. (Including quantitative norms and/or ranges of values for each variable.)

B. Historical Data on Disruption in Combat

1. Preparation of a list of potential case studies for a data base. (The starting point would be the list in Section II of this study.)
2. Establishment of data requirements. (This would be a check list regarding the kinds of data desired, and the levels at which the data should be resolved.)
3. Case study analyses. (These would be similar to the analyses in Study A, but with the additional requirement to produce a list of data based upon Step 2, above. This step of the study can be as long or as exhaustive as funds will permit, with the decision as to the allocation of resources dependent upon the recommendations of statisticians and operations analysts; if necessary, these individual case study analyses can be spread out over a long period of time, and be derived from other studies in the program.)
4. Compilation of data. (This compilation can be open-ended, and the data base can be enriched over a period of time, as suggested above.)
5. Analysis of data. (The initial analysis will be in terms of the objectives of the research program; the data base will be available, however, to an almost unlimited variety of analyses.)

C. The Scope and Nature of Disruption

The purpose of this study would be to analyze a variety of disruptive actions which have caused (or threatened) disruption, with a view to answering the kinds of questions that are raised about this subject

on pp. 25-26 above. This is an analysis that flows logically from the previous study, from which its examples would be selected. It should not, however, be considered as a sub-study of the previous study since it is much more precisely focussed, and since responses to the questions raised about the scope and nature of disruption appear to be so fundamental to an understanding of the subject.]

D. Relative Disruptive Effects of Air Bombardment and Artillery Fire

[This study would review the record to find instances of effective artillery disruption and effective close air support disruption and compare the disruptive effects in terms of effort, casualties, and costs.]

E. Disruption in Weapons Trade-Offs

[This study would be related to the previous one, and would almost certainly take advantage of its results; the purpose, however, would be more ambitious, in that an effort would be made to ascertain how--at least in so far as disruptive effort is concerned--one type of weapon, or some kind of weapons or force mix, might in specific combat situations be substituted effectively for another type of weapon or kind of weapons or force mix.]

F. Cost Effectiveness Comparison of Disruptive and Destructive Technique

[This study would explore the extent to which there are differences in techniques for disruptive, as opposed to destructive, purposes, and would then attempt to evaluate these different techniques in cost-effective terms; the analysis would have to make clear any adverse implications in adoption of the most cost-effective techniques.]

G. Relationship of Casualties and Combat Effectiveness

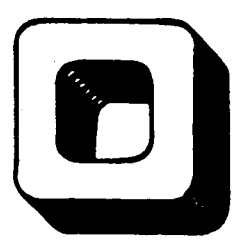
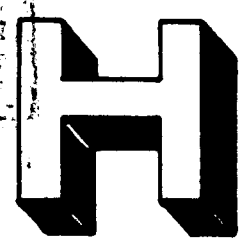
[One assumption upon which this study would almost certainly be

based is that combat effectiveness comprises a mixture of quantitative and qualitative elements. The qualitative elements are susceptible to disruptive forces. The study would endeavor to ascertain the extent to which casualties have an adverse morale effect upon combat effectiveness, as opposed to the quantitative effect of reduced force strength.]

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54 Comparative Analysis: Arab and Israeli
Combat Performance 1967 and 1973 Wars
(1976)

COMPARATIVE ANALYSIS
ARAB AND ISRAELI COMBAT PERFORMANCE
1967 AND 1973 WARS

A Report Prepared for
Office, Assistant Secretary of Defense
June 1976
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HISTORICAL EVALUATION AND RESEARCH ORGANIZATION

ERRATA

Comparative Analysis Arab and Israeli Combat Performance 1967 and 1973 Wars

<u>Page</u>	<u>Figure</u>	<u>Change</u>
7	2	Column 7 heading from 1/12 Div to read 1/8 Div 1/36 Bde 1/24 Bde
9	6	Eng. No. 67-2 should read Abu Ageila-Um Katef
10	8	June 8, columns 3 and 4 should read 10.1(100) and 10.1(4) respectively
10	9	June 5 line should read across: 28, 78, (1)18, 1(46), (10), (32), ..., ..., ..
23	33	For engagements 22, 23, 24, change Arab CEV column to read down: 1.70, 0.73, 0.26
23	33	For engagements 22, 23, 24, change Israeli CEV column to read down: 0.59, 1.36, 3.85
24	35	For 1967 - West Bank (far left column) change Israeli CEV to 1.95 (far right column)
26	last para.	Change first line to read: In 1970, following an equally dismal performance against Jordan, there had been one more coup d'etat, led this time by the then Minister of War, Air Force General Hafez al Assad.

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COMPARATIVE ANALYSIS, ARAB AND ISRAELI COMBAT PERFORMANCE
1967 AND 1973 WARS

A HERO Report

INTRODUCTION

OBJECTIVE

The purpose of this study by the Historical Evaluation and Research Organization (HERO), was stated in the Task Order to be as follows:

Utilizing data already available to HERO, with such additions and refinements as are mutually agreed by HERO and OASD(I) to be necessary and feasible within budgetary limits of the study, HERO will analyze approximately ten engagements, each, at brigade level or higher, for the 1967 Six Day War, and the 1973 October War, employing both the Quantified Judgment Method of Analysis of Historical Combat Data (QJMA) and qualitative historical analytical techniques, in order to ascertain the following:

- a. Relative combat effectiveness of the opposed forces in each engagement;
- b. Patterns or differences in relative combat effectiveness of different Arab units and armies;
- c. Patterns or differences between relative Arab-Israeli combat performance in 1967 and in 1973;
- d. The extent to which Arab and Israeli relative performance changed between offensive and defensive postures;
- e. The extent to which the presence or lack of airpower appears to have influenced combat outcomes;
- f. The extent to which outcomes were influenced by any other variables of combat.

The tasks to be performed and the procedures to be followed, according to the Task Order, were:

1. Compilation of data; to include such additions or refinements of existing HERO data as may be necessary, assuring compatibility, to the extent possible, with data used in ongoing analyses of the Middle East Balance;
2. Quantitative analysis of the 1967 War data by QJM;
3. Qualitative analysis of 1967 War data;
4. Quantitative analysis of 1973 War data by QJM;
5. Qualitative analysis of 1973 War data;
6. Comparative evaluation of results of steps 2-5, inclusive;
7. Preparation of Report.

DATA SOURCES

In the performance of Step 1, data on the 1973 war already available to HERO was reviewed and refined on the basis of information collected for a report on "The Middle East War in Historical Perspective," prepared for the Director of Net Assessment, Department of Defense, and additional information received in conversations with Major General Avraham Adan, Israeli Army, and Colonel Avraham Ayalon, Israeli Army.

Data on the 1967 War is that compiled in an unpublished operational narrative of that war prepared by Colonel T.N. Dupuy, USA, Ret., with assistance of members of the HERO staff, which has been reviewed and commented on by military officials of the Israeli, Egyptian and Jordanian armed forces.

A cursory check of some items of classified data on the October War led to a conclusion that the HERO unclassified data is probably just as accurate; thus no classified data was used in the study, and accordingly this report is not classified.

PARTICIPANTS

Most of the work on this study and this report was done by Colonel T.N. Dupuy, USA, Ret., and Colonel John A.C. Andrews, USAF, Ret. Contributions to the study were also made by Grace P. Hayes and Vivian Lyons, of the HERO staff. The undersigned takes full responsibility for the results of the study and this report.

Dunn Loring, Virginia
15 June 1976

T.N. Dupuy
Executive Director

COMBAT PERFORMANCES IN THE 1967 WAR

THE DATA

Figure 1 is a summary of major statistical data of the 1967 "Six Day War," including overall strengths and losses of personnel and selected major items of equipment for all major participants. Figures 2, 3, 4, and 5 present more detailed listings of the principal varieties of weapons and combat equipment estimated to be on hand in the Israeli, Egyptian, Jordanian and Syrian armies as of 1 June 1967, showing presumed allocations to major combat formations, such as divisions and brigades.

Figure 6 is a listing of all major engagements on all three fronts, between June 5 and June 10. Figure 7 is an estimated breakdown of the presumed total Israeli and Egyptian casualties on the Sinai front, with allocations to days and engagements based upon professional historical and military judgment in consideration of the Dupuy detailed narrative of operations cited under "Data sources" in the Introduction to this report. Figure 8 is a comparable breakdown of presumed Israeli and Egyptian tank losses on the Sinai front, by day and by engagement. Figure 9 is a comparable breakdown of estimated direct air support allocations by the Israeli and Egyptian air forces, also related to engagements and dates.

Figures 10, 11, and 12 provide comparable data estimates for the Jordan, West Bank, Front, June 5-7, 1967. Figures 13, 14, and 15 provide comparable data estimates for the Syrian, Golan, Front, June 9-10, 1967.

Available resources of time and funds permitted analysis of only twelve engagements of the 1967 War—four on each front. This was a total of two more 1967 War engagement analyses than was provided for in the Task Order.

DATA ANALYSIS

Figure 16 is a sample engagement data sheet for Engagement 67-1, the Battle of Rafa, June 6, 1967. Figure 17 is a sample engagement calculation sheet for the engagement, showing the application of the data to the formulae of the Quantified Judgment Model (QJM). The entries for Figure 18, "Preliminary 1967 Arab-Israeli War Analysis," are derived from these and comparable data and calculation sheets for the other eleven engagements. That figure provides a summation of the QJM analyses of these engagements, and is the essence of this study's quantitative analysis of the 1967 War.

The columns of Figure 18 are described as follows:

1. Engagement number (see Figure 6)
2. Numerical manpower comparison (Arab with respect to Israeli)
3. Firepower comparison ratio
4. Relative Combat Power, basic calculation, in which all readily-identifiable combat variables have been considered;
5. The effects of surprise, reflecting effects of surprise on relative mobility and vulnerabilities of the opponents as calculated for World War II engagements.¹
6. Modified Combat Power Ratio (to reflect effects of surprise)
7. Engagement outcomes
8. Effective Combat Power Ratio; the ratio that would have been required for average ratio-result relationship in World War II engagement data base ($(R - R)/5 + 1$)
9. Arab Combat Effectiveness Value (CEV); calculated by dividing entry in column 8 by that in column 6.
10. Israeli CEV (reciprocal of Arab CEV)

¹See, T.N. Dupuy, The Quantified Judgment Method of Analysis of Historical Combat Data. HERO, Dunn Loring, Va., 1976.

During the process of analysis of the data in Figure 18, and that of Figure 34 (containing similar analytical data from 1973 War engagement analyses), three analytical hypotheses have been formulated:

1. Arab performance in situations and circumstances in which they were following carefully prepared pre-war plans was substantially better than when coping with unanticipated combat situations; this ability is estimated at about a 30% improvement over standard performance in pre-planned operations.²

2. The effects of surprise in 1967 and 1973 combat situations was clearly more significant than it had been in combat between the Germans and the Western Allies in 1943 and 1944; this increase appeared to be proportional to the greater average dispersion of troops in these wars (about 4,000 square meters per man) than in World War II (about 3,000 square meters per man). This enhanced value of surprise in an increasingly scientific-technical environment seems to be consistent with Soviet assessments, as represented by the following quotation from Scientific-Technical Progress and the Revolution in Military Affairs by Colonel General N.A. Lomov (Moscow, 1973):

Scientific-technical progress is the material basis of those revolutionary changes which have occurred in the Soviet Armed Forces in recent years. . . . /This/ revolution in military affairs to a significant degree has raised the importance of surprise. High combat readiness of the Soviet Armed Forces is caused by the most important of all the tasks confronting them—that is, to thwart the intentions and provide a decisive and complete defeat to any aggressor. The present capabilities of the Soviet Armed Forces make it possible to solve this problem.

3. The disruptive effects of surprise evidently continue for at least two days after the surprise is achieved. For the first day it is about two-thirds the disruptive effect of the surprise as calculated for the day it occurs, and about one-third the initial surprise disruptive effect on the second day after surprise is achieved.

The application of these hypotheses to the analytical results of Figure 18 provides somewhat refined values for combat effectiveness, as shown in Figure 19.

The refined analysis reflected by the values in Figure 19 shows remarkably consistent values in relative combat effectiveness of the opponents within each of the three sets of four engagements on the three separate fronts. It shows that the Israeli combat effectiveness superiority over the Egyptians was on the average 96%, or a CEV of 1.96; their superiority over the Jordanians was on the average 63%, or a CEV of 1.63; Israeli superiority over the Syrians was on the average 313%, or a CEV of 4.13.

Normalizing these relationships on the Syrian performance provides the following interesting comparison:

Israelis	4.13	(1.63)	(1.96)	
Jordanian	2.53	(1.00)	--	(1.20)
Egyptian	2.11	--	(1.00)	(1.00)
Syrian	1.00			

²This phenomenon has also been noted in World War II engagements between Russian and German forces, supporting a more general hypothesis: when a force of lower combat effectiveness is able to seize the initiative and operate in accordance with carefully prepared plans for either offense or defense, the combat effectiveness differential is reduced by one-third.

Figure 1. APPROXIMATE FORCE STRENGTHS, SIX-DAY WAR, 1967

Available	Israel	Total Arabs	Egypt	Jordan	Syria	Iraq
Mobilized Manpower	210,000	309,000	200,000	46,000	63,000	--
Tanks	1,000 ^a	2,337	1,300 ^d	287 ^f	750	--
APC	1,500 ^b	1,845	1,050	210	585	--
Artillery Pieces	203	962	575	72	315	--
SAM	50	160	160	0	0	--
AA Guns	550	2,050 ⁺	950	?	1,100	--
Combat Aircraft	286 ^c	682	431 ^e	18	127 ^g	106

^a200 M-48, 250 Centurions, 150 AMX-13, 400 Sherman-Super Sherman.

^bHalftracks.

^cIncludes 92 Mirage, 24 Super Mystere, 72 Mystere, 55 Ouragan, 24 light bombers.

^dIncludes 400 T-34, 450 T-54/55, 100 Su-100, 100 JS-3.

^eIncludes 55 Su-7, 163 MiG-21, 40 MiG-19, 100 MiG-15/17, 30 Tu-16, 43 Il-28; short of pilots.

^fIncludes 200 M-48, 80 Centurions.

^gIncludes 40 supersonic, 68 MiG-15/17, 15 Tu-16, 4 Il-28.

Figure 2. ESTIMATED ISRAELI ARMAMENT SUMMARIES, 1967

	Inf Bde	Meczd Bde	Armd Bde	Armd Rgt	Arty Rgt	1/12 Div 1/36 Bde Misc Units	9 Arty Rgts	2 Armd Rgts	14 Inf/Para Bde	2 Meczd Bde	8 Armd Bde	Totals
Personnel	4,300	4,300	3,600	2,000	1,000	25,000	9,000	4,000	60,200	8,600	28,800	135,600
Pistol	430	430	360	200	100	2,500	900	400	6,020	860	2,880	13,560
Rifle	3,870	3,870	3,240	1,800	900	22,500	8,100	3,600	54,180	7,740	25,920	122,040
Machine Gun, lt	120	80	40	30	10	250	270	60	1,680	160	320	2,740
Machine Gun, hvy	80	60	40	30	20	420	270	60	1,120	120	320	2,310
Mortar, 81mm	20	10	..	..	..	..	..	..	280	20	..	300
Mortar, 4.2"	12	8	..	..	..	..	..	..	168	16	..	184
Bazooka	20	10	..	..	5	45	45	..	280	20	..	390
AT Missile SS-10/11	12	4	..	..	..	78	..	..	168	8	..	254
RR, 106mm	6	4	..	..	..	..	..	..	84	8	..	92
APC, Halftrack	50	200	20	12	3	126	27	24	700	400	160	1,437
AA, lt, 20mm	16	12	12	6	2	140	18	12	224	24	96	514
AA, lt, 40mm	..	..	..	..	4	76	36	..	..	..	..	112
Hawk	..	..	..	..	..	50	..	..	..	..	..	50
How, 105mm	..	..	..	..	..	..	(4)96	..	..	..	..	96
How, 155mm	..	..	..	..	..	..	(3)72	..	..	..	..	72
Gun, 155mm	..	..	..	..	..	..	(1)24	..	..	..	..	24
Gun, 175mm	..	..	..	..	..	..	(1)12	..	..	..	..	12
Tanks	10	30	90	40	..	..	..	80	140	60	720	1,000
AMX-113	..	10	(30)	(40)(10)	..	..	..	(80)(20)	..	20	(240)	150
M-48 (90)	..	..	..	..	..	..	..	..	..	..	..	200
Super Sherman	10	20	(90)(60)	(30)	..	..	..	(60)	140	40	(720)(480)	400
Centurion	..	..	..	..	..	..	..	..	..	..	..	250
APC, Halftrack	50	200	20	12	3	125	27	24	700	400	160	1,436
Trucks	150	150	150	75	100	2,500	900	150	2,100	300	1,200	8,586
SP Mounts	30	30	38	19	25	200	225	38	420	76	304	1,263

Figure 3. ESTIMATED EGYPTIAN ARMAMENT SUMMARIES, 1967

	Inf Div	Tank Div	Tank Bde	Inf Bde	Arty Rgt	1/10 Div Misc Units	15 Arty Rgts	5 Inf Divs	2 Tank Divs	5 Inf Bdes	7 Tank Bdes	Totals
Personnel	10,000	10,000	3,500	4,000	1,000	15,000	15,000	50,000	20,000	20,000	24,500	144,500
Pistol	1,000	1,000	350	400	100	1,500	1,500	5,000	2,000	2,000	2,450	14,450
Rifle	9,000	9,000	3,150	3,600	900	13,500	13,500	45,000	18,000	18,000	22,050	130,050
Machine Gun, lt	360	270	85	120	75	200	1,125	1,800	540	600	595	4,860
Machine Gun, hvy	240	160	55	80	75	150	1,125	1,200	320	400	385	3,580
Mortar, 2"	20	10	12	10	..	50	..	100	20	50	84	304
Mortar, 82mm	50	..	..	16	..	..	..	250	..	80	..	330
Mortar, 120mm	12	..	..	4	..	..	..	60	..	20	..	80
RL, 40mm	50	10	..	16	10	100	150	250	20	80	..	600
GAT, 85mm	48	24	..	24	..	..	..	240	48	120	..	408
Schmel AT Missile	24	12	..	8	..	..	..	120	24	40	..	184
RR, 107mm	24	12	..	8	..	..	..	120	24	40	..	184
AMG ZPU-2	9	9	6	6	6	100	90	45	18	30	42	325
AAMG ZPU-4	9	9	..	..	..	100	..	45	18	..	..	163
AA, 37mm	6	6	..	..	..	50	..	30	12	..	..	92
AA, 57mm	12	6	..	..	..	50	..	60	12	..	..	122
AA, 85mm	..	..	..	..	..	..	(5)120	..	..	..	..	120
Mortar, 240mm	..	..	..	..	..	..	(4) 96	..	..	..	..	96
How, 122mm	54	36	..	..	..	..	(3) 72	270	72	..	..	414
Gun How, 15 mm	12	..	..	..	..	..	(2) 48	60	..	..	..	108
Gun, 130mm	..	..	..	..	..	..	(1) 24	..	..	..	..	24
AT Su-100 SP	12	10	..	4	..	..	..	60	20	20	..	100
JS-3	12	10	..	4	..	..	..	60	20	20	..	100
PT-76	..	30	10	..	..	..	..	60	..	..	70	130
T-34	20	100	30	..	..	..	..	100	200	..	210	510
T-54/55	..	150	50	..	..	..	..	..	300	..	350	650
APC BTR-50	120	30	10	30	3	..	45	600	60	150	70	925
APC BTR-152	20	10	2	..	..	..	..	100	20	..	14	134
Truck	800	600	200	250	100	500	1,500	4,000	1,800	1,250	1,400	10,450
Motorcycle	60	50	20	20	..	30	..	300	100	100	140	670
SP Mount	36	30	..	10	12	50	180	180	60	50	..	520

Figure 4. ESTIMATED JORDANIAN ARMAMENT SUMMARIES, 1967

	Inf Bde	Armd Bde	Arty Bn	1/10 Bde Misc Units	8 Inf Bdes	2 Armd Bdes	4 Arty Bns	Totals
Personnel	4,500	4,000	500	2,000	36,000	8,000	2,000	48,000
Pistol	450	400	50	200	3,600	800	200	4,800
Rifle	4,050	3,600	450	1,800	32,400	7,200	1,800	43,200
Machine Gun, lt	120	40	10	25	960	80	40	1,105
Machine Gun, hvy	80	40	20	42	640	80	80	842
Mortar, 81mm	20	10	..	..	160	20	..	180
Mortar 4.2"	12	8	..	..	96	16	..	112
Bazooka	20	10	5	10	160	20	20	210
RR, 106mm	6	4	..	..	48	8	..	56
AA, lt, 20mm	16	12	6	12	128	24	24	188
AA, lt, 40mm	..	..	..	12	..	..	..	12
Gun, 25 pdr	12	..	..	..	(6)72	..	..	72
How, 105mm	..	..	(12)	..	(2)24	..	(1)12	36
How, 155mm	..	..	..	..	..	..	(2)24	24
Gun, 155mm	..	..	(8)	..	..	..	(1) 8	8
Tanks	..	..	..	..	..	..	..	240
M-48	..	90	..	..	..	180	..	180
Centurion	..	30	..	..	..	60	..	60
Trucks	150	150	50	250	1,200	300	20	1,770
SP Mounts	20	20	..	20	160	40	..	220
APC, M113, Saracen	50	20	..	10	400	40	..	540

Figure 5. ESTIMATED SYRIAN ARMAMENT SUMMARIES, 1967

	Inf Bde	Meczd Bde	Tank Bde	Arty Rgt	1/11 Bde Misc Units	10 Arty Bde	6 Inf Bde	3 Meczd Bde	3 Tank Bde	Totals
Personnel	4,000	4,500	3,500	800	4,000	8,000	24,000	13,500	10,500	60,000
Pistol	400	450	350	80	400	800	2,400	1,350	1,050	6,000
Rifle	3,600	4,050	3,150	720	3,600	7,200	21,600	12,150	9,450	54,000
Machine Gun, lt	270	300	85	75	50	750	1,620	900	255	3,575
Machine Gun, hvy	160	180	55	75	40	750	960	900	165	2,815
Mortar, 82mm	20	20	..	..	..	..	120	60	..	180
Mortar, 120mm	4	4	..	..	..	..	24	12	..	36
RL, 40mm	16	16	10	10	25	100	96	48	30	299
GAT, 85mm	32	32	..	..	..	..	192	96	..	288
RR, 107mm	8	8	8	..	..	..	48	24	24	96
AAMG ZPU-2	6	6	3	6	25	60	36	18	9	148
AAMG ZPU-4	6	6	3	..	25	..	36	18	9	88
AA, 37mm	4	4	4	..	20	..	24	12	12	68
AA, 57mm	4	4	..	..	20	..	24	12	..	56
AA, 85mm	..	..	..	..	(2)48	..	..	..	..	48
Mortar, 240mm	..	..	..	..	..	(1)24	..	..	..	24
Katushya	..	..	..	..	..	(1) 8	..	..	..	8
How, 122mm	12	12	..	..	..	(4)96	72	36	..	204
Gun How, 152mm	..	..	..	..	..	(3)72	..	..	..	72
Gun, 130mm	..	..	..	..	..	(1)24	..	..	..	24
AT Su-100 SP	12	12	12	..	..	..	72	36	36	144
JS-3	8	8	24	..	..	..	48	24	72	144
PT 76	..	10	10	..	..	..	..	30	30	60
T-34	30	..	30	..	..	..	180	..	90	270
T-54/55	..	60	60	..	..	..	..	180	180	360
APC BTR-50	40	60	20	3	10	30	240	180	60	520
APC BTR-152	10	10	5	..	2	..	60	30	15	107
Truck	250	275	250	100	120	1,000	1,500	825	750	4,195
Motorcycle	20	20	20	..	10	..	120	60	60	250
SP Mount	10	20	10	12	12	120	60	60	30	282

Figure 6. ENGAGEMENTS, SIX-DAY WAR, JUNE 1967

Eng No	Date	Engagement Designation	Arab Forces	Israeli Forces
<u>Sinai</u>	June		<u>Egyptian</u>	
67- 1	5	Rafah	PLA & 7 Inf Div	Tal's Div
67- 2	5/6	Aby Ageila-Um Katef	2 Inf Div	Sharon's Div
67- 3	5-7	Gaza Strip	PLA Div	Tal's Div
67- 4	5/6	El Arish	7 Inf Div	Tal's Div
67- 5	5/6	Bir Lahfan	3 Inf Div	Yoffe's Div
67- 6	6	Jebel Libni	3 Inf Div	Yoffe's Div
67- 7	7	Bir Hama-Bir Gifgafa	3 Inf Div & 21 Tank Div	Tal's Div
67- 8	7	Bir Hassna-Bir Thamada	3 Inf Div & 4 Tank Div	Yoffe's Div
67- 9	7/8	Mitla Pass	3 Inf, 6 Inf Divs	Yoffe's Div
67-10	8	Bir Gifgafa	4 Tank Div	Tal's Div
67-10.1	8	Nakhl	6 Meczd Div	Sharon's Div
<u>Jerusalem- West Bank</u>			<u>Jordanian</u>	
67-11	5-7	Jerusalem	Jerusalem Bde(+)	Central Command
67-12	5/6	Jenin	25 Inf Bde	Peled's Div
67-13	6/7	Kabatiya	40 Armd Bde, 25 Inf Bde	Peled's Div
67-14	6/7	Tilfit-Zababida	40 Armd Bde, 25 Inf Bde	Ram's Bde
67-15	7	Nablus	Brigade equiv	Ram's Bde, Kochva's Bde
<u>Golan Hts</u>			<u>Syrian</u>	
67-21	9	Zaoura-Kala	11 Inf Bde	Mendler's Bde
67-22	9	Tel Fahar	11 Inf Bde	Golani Bde
67-23	9	Rawiya	8 Inf Bde	Ram's Bde
67-24	10	Banias-Masaada	11 Inf Bde	Golani Bde
67-25	10	Kuneitra	Syrian Meczd Bde	Mendler's Bde
67-26	10	Boutmiya	Syrian Armd Bde	Peled's Div

Figure 7. ESTIMATED ALLOCATION OF BATTLE CASUALTIES, SINAI FRONT, JUNE 5-8, 1967, INCLUSIVE

Date	Engagements								Egyptian			Israeli		
	Egypt	Israel	Egypt	Israel	Egypt	Israel	Egypt	Israel	Daily Eng	Daily Misc	Cumulative	Daily Eng	Daily Misc	Cumulative
June 5	(1) 3,000	(1) 500	(2) 1,000	(2) 200	(3) 250	(3) 45	(4) 250	(4) 85	3,000	..	3,000	500	..	500
	..	..	..	..	..	..	..	..	1,500	..	4,500	300	30	860
6	..	..	..	..	(3) 500	(3) 20	..	..	500	500	5,500	20	..	880
	(5) 500	(5) 50	..	..	..	..	..	..	500	..	6,000	50	..	930
7	(6) 500	(6) 40	(7) 600	(7) 45	(8) 600	(8) 30	(9) 600	(9) 60	1,700	1,500	9,200	115	10	1,045
	..	..	..	..	..	..	..	..	600	..	9,800	60	..	1,105
8	(10) 500	(10) 40	(11) 684	(11) 24	..	..	..	..	1,184	1,900	12,884	64	15	1,194

Figure 8. ESTIMATED ALLOCATION OF TANK LOSSES, SINAI FRONT, JUNE 5-8, 1967, INCLUSIVE

Date	Engagement								Egyptian				Israeli			
	Egypt	Israel	Egypt	Israel	Egypt	Israel	Egypt	Israel	Daily Loss	Cum Loss	Daily Return	Cum Net Loss	Daily Loss	Cum Loss	Daily Return	Cum Net Loss
June 5	(1) 70	(1) 15	(2) 40	(2) 19	(3) 60	(3) 4	(4) 80	(4) 13	70	70	..	70	15	15	..	15
	..	..	..	..	..	..	..	..	180	250	..	250	36	51	..	51
6	..	..	..	..	(3) 30	(3) 4	..	..	30	280	5	275	4	55	2	53
	(5) 30	(5) 11	..	..	..	..	..	..	30	310	..	305	11	66	..	64
7	(6) 30	(6) 10	(7) 30	(7) 5	(8) 30	(8) 10	(9) 100	(9) 16	90	400	18	377	25	91	6	83
	..	..	..	..	..	..	..	..	100	500	..	477	16	107	..	99
8	(10) 100	(10) 11	(11) 100	(11) 4	..	..	..	..	200	700	27	650	15	122	9	105
	..	..	..	..	..	..	..	..	..	..	10	640	..	..	44	61

Figure 9. ESTIMATED CLOSE AIR SUPPORT FIGHTER-BOMBER SORTIES
SUEZ-SINAI FRONT, JUNE 5-8, 1967, INCLUSIVE

Date	Available Sorties		Engagements							
	Egypt	Israel	Egypt	Israel	Egypt	Israel	Egypt	Israel	Egypt	Israel
June 5	61	78	(1) 51	(1) 78	(2) 0	(2) 0	(3) 10	(3) 38	(4) 0	(4) 38
	..	..	..	..	..	..	..	..	..	..
6	20	152	(5) 20	(5) 76	..	..	..	..	..	..
7	0	152	(6) 0	(6) 52	(7) 0	(7) 40	(8) 0	(8) 40	(9) 0	(9) 20
8	0	245	(10) 0	(10) 123	(11) 0	(11) 122	..	..	..	..

Figure 10. ESTIMATED ALLOCATION OF BATTLE CASUALTIES, JORDAN FRONT, JUNE 5-7, 1967, INCLUSIVE

Date	Engagements								Jordanian			Israeli		
	Jordan	Israel	Jordan	Israel	Jordan	Israel	Jordan	Israel	Daily Eng	Daily Misc	Cumulative	Daily Eng	Daily Misc	Cumulative
June 5	(11) 1,500	(11) 600	(12) 800	(12) 400	..	..	..	..	1,500	1,000	3,000	600	100	700
	..	..	..	..	..	..	..	..	800	1,200	4,500	400	..	1,100
6	(11) 1,000	(11) 800	..	..	(13) 1,000	(13) 550	(14) 500	(14) 253	2,500	1,000	8,000	1,603	100	2,803
	..	..	..	..	..	..	..	..	..	1,000	9,000	..	..	..
7	(11) 1,000	(11) 350	(15) 1,000	(15) 600	..	..	..	..	2,000	2,000	13,000	950	100	3,853

Figure 11. ESTIMATED ALLOCATION OF TANK LOSSES, JORDAN FRONT, JUNE 5-7, 1967, INCLUSIVE

Date	Engagement								Jordanian				Israeli			
	Jordan	Israel	Jordan	Israel	Jordan	Israel	Jordan	Israel	Daily Loss	Cum Loss	Daily Return	Cum Net Loss	Daily Loss	Cum Loss	Daily Return	Cum Net Loss
June 5	(11)50	(11)20	(12)40	(12)18	..	..	..	..	50	50	..	50	20	20	..	20
	..	..	..	..	..	..	..	..	40	90	..	90	18	38	..	38
6	(11)20	(11)10	..	..	(13)44	(13)18	(14)36	(14)18	100	190	6	184	46	84	6	78
7	(11)20	(11)10	(15)46	(15)18	..	..	..	..	66	256	12	238	28	112	10	96
											10	228			40	56

Figure 12. ESTIMATED CLOSE AIR SUPPORT FIGHTER-BOMBER SORTIES
JORDANIAN FRONT, JUNE 5-7, 1967, INCLUSIVE

Date	Available Sorties		Engagements							
	Jordan	Israel	Jordan	Israel	Jordan	Israel	Jordan	Israel	Jordan	Israel
June 5	11	76	(11) 11	(11) 38	(12) 0	(12) 0	..	..	..	..
	..	..	..	38	..	..	..	..	..	..
6	0	112	(11) 0	(11) 40	..	..	(13) 0	(13) 21	(14) 0	(14) 21
	..	..	..	30	..	..	..	..	..	..
7	0	104	(11) 0	(11) 52	(15) 0	(15) 52	..	..	..	..

Figure 13. ESTIMATED ALLOCATION OF BATTLE CASUALTIES, GOLAN FRONT, JUNE 9-10, 1967, INCLUSIVE

Date	Engagements								Syrian		Israeli			
	Syria	Israel	Syria	Israel	Syria	Israel	Syria	Israel	Daily Eng	Misc	Cumulative	Daily Eng	Misc	Cumulative
June 9	(21)1,000	(21)100	(22)1,500	(22)150	(22) 600	(23) 68	..	..	2,500	1,000	3,500	250	..	250
	..	..	..	..	..	..	..	..	600	400	4,500	68	..	318
10	(24) 500	(24) 50	(25) 500	(25) 50	(26) 500	(26) 50	..	..	1,500	600	6,600	150	..	468

Figure 14. ESTIMATED ALLOCATION OF TANK LOSSES, SYRIAN FRONT, JUNE 9-10, 1967, INCLUSIVE

Date	Engagement								Syrian				Israeli			
	Syria	Israel	Syria	Israel	Syria	Israel	Syria	Israel	Daily Loss	Cum Loss	Daily Return	Cum Net Loss	Daily Loss	Cum Loss	Daily Return	Cum Net Loss
June 9	(21)15	(21)40	(22)10	(22) 5	..	(23)10	(23)10	..	25	25	..	25	45	45	..	45
	..	..	..	..	(23)10	(23)10	..	..	10	35	..	35	10	55	..	55
10	(24)15	(24)35	(25)20	(25)35	(26)30	(26)35	..	..	65	100	3	97	105	160	6	154
											5	92			74	80

Figure 15. ESTIMATED CLOSE AIR SUPPORT FIGHTER-BOMBER SORTIES
GOLAN FRONT, JUNE 9-10, 1967, INCLUSIVE

Date	Available Sorties		Engagements							
	Syria	Israel	Syria	Israel	Syria	Israel	Syria	Israel	Syria	Israel
June 9	0	238	(21) 0	(21)119	(22) 0	(22)119	(23) 0	(23) 0		
10	0	231	(24) 0	(24) 77	(25) 0	(25) 77	(26) 0	(26) 77		

Figure 16. ENGAGEMENT DATA CALCULATION INPUT SHEET

Engagement No: 67-1 Date of Calc: 17 May '76
 Engagement Date: 5 June 1967
 Terrain: Flat Mixed/Desert
 Posture: Fort/ Prepared Defense
 Weather: Hot, Dry
 Season: Spring
 Unit: 7th Div (-) & PLA Div (-), Egypt
 Depth: 8.8 Q: -45
 Personnel Losses: 3,000
 Tank Losses: 70
 Mission Factor: 2

	OLI	Number	Total OLI
N Personnel		19,500	
W _s Pistol, Beretta	0.03	1,950	59
Rifle, AK-47	0.26	17,550	4,563
W _{mg} MG Lt., SGM 7.62	0.58	485	281
MG Hvy., DK 12.7	0.89	323	287
W _{hw} Mortar, 50mm	27	48	1,296
Mortar, 82mm	44	47	2,068
Mortar, 120mm	58	12	696
APC, BTR-50	58	109	6,322
APC, BTR-152	23	9	207
W _{gi} RL, 40mm	20	60	1,200
Schmel AT Missile	34	23	782
RR, 107mm	101	23	2,323
Gun AT, D-48, 85mm	192	62	11,904
Gun, 100mm	229	12	2,748
How, M-38, 122mm	159	52	8,268
Gun How, D-20, 152mm	231	4	924
W _{gy} MMG, ZPU-2	27	36	972
AAMG, ZPU-4	37	16	592
AAG, 37mm	66	8	528
Gun AA S-60, 57mm	168	10	1,680
W _i Gun, AT, SP, SU-100 (TD)	388	12	4,656
Tank Hvy, T-10/JS-3 av.	281	12	3,372
Tank Lt, PT-76	212	13	2,756
Tank, T-34	280	45	12,600
Tank, Sherman	210	50	10,500
Tank, T-54)	av. 505	65	32,825
Tank, T-55)			
W _y MiG-17	731	18/2	6,579
Total OLI			120,988
J Trucks		1,209	
APC, Tack, Halftrack		155	
Motorcycle		88	
Helicopters		22	

Engagement No: 67-1 Date of Calc: 17 May '76
 Engagement Date: 5 June 1967
 Terrain: Flat Mixed/Desert
 Posture: Attack
 Weather: Hot, Dry
 Season: Spring
 Unit: Tal Div, Israel
 Depth: 8.8 Q: 45
 Personnel Losses: 500
 Tank Losses: 15
 Mission Factor: 9

	OLI	Number	Total OLI
N Personnel		19,520	
W _s Pistol, cal .45	0.02	1,952	39
Rifle, Galil	0.22	17,568	3,865
W _{mg} Machine gun, cal 7.62mm	0.82	283	232
Machine gun, cal 12.7mm	1.04	292	304
W _{hw} Mortar, 81mm	50	20	1,000
Mortar, 4.2" (107mm)	90	12	1,080
Halftrack, M3	27	125	3,375
W _{gi} Bazooka	14	41	574
ATM SS 10/11	34	18	612
RR-SP, 106mm	133	6	798
W _g How SP, 105mm	160	48	7,680
How SP, 155mm	235	24	5,640
Gun SP, 155mm	303	12	3,636
W _{gy} Gun AA, SP, Lt 20mm	124	67	8,308
Gun AA, SP, Lt 40mm	146	20	2,920
SAM, Hawk	300	4	1,200
W _i Tank, M4 (105mm)	470	45	21,150
Tank, M48 (90mm)	474	45	21,330
Tank, Centurion	536	45	24,120
Tank, AMX-13 (90mm)	321	105	33,705
W _y Mystere IV	1,404	23/2	17,963
Super-Mystere	1,562	23/2	16,146
Total OLI			175,677
J Trucks		1,105	
APC, Track, Halftrack		361	
Helicopters		39	

Figure 17. MODEL (ENGAGEMENT) CALCULATION FORM

Engagement: No. <u>67-1</u>	Engagement Date: <u>5 June 1967</u>	Calculation Date: <u>17 May 1976</u>
Egyptian Unit: <u>7th Div(-), PLA Div (-)</u>	Posture: <u>Fort/Prep Def</u>	Israeli Unit: <u>Tal Division</u>
Mission Factor <u>2</u>		Mission Factor <u>9</u>

$S_f = (W_s + W_{mg} + W_{hw} + W_{gi}) \times r_n$ $(4622 + 568 + 10589 + 16209) \times .95$ $(W_g + W_{gy}) (r_{wg} \times h_{wg} \times z_{wg} \times w_{yg})$ $(11940 + 3772)(1 \times 1 \times 1 \times .9)$ $W_i \times r_{wi} \times h_{wi}$ $66709 \times .95 \times 1$ $W_y \times r_{wy} \times h_{wy} \times z_{wy} \times w_{yy}$ $6579 \times 1 \times 1 \times 1 \times .8$ $S_f \text{ (total)}$	$= 30,389$ $= 14,141$ $= 63,373$ $= 5,263$ $= 113,166$

$V_f = N_f \times u_v/r_u \times \sqrt{S_e/S_f} \times v_y \times v_r$ $19500 \times .55/1.19 \times 1.2371 \times 1.1 \times 1$ $v_f = 1 - V_f/S_f = 1-.1094$ $M_F = (N_f + 12J + W_i) \times m_{yf}/N_f$ $[9600 + 12(1209 + 310 + 220) + 66709] \times .9/19500$ $m_d = 1$ $M_a = \sqrt{M_d/M_d} = \sqrt{1.6615}$ $P_f = S_f \times m \times l \times e \times t \times o \times b \times u_s \times r_u \times h_u \times z_u \times v_f$ $113,116 \times 1 \times 1 \times 1 \times 1 \times 1 \times 1.55 \times 1.19 \times 1 \times 1 \times .7812$ $P_f/P_e = .092$	$= 4.9664$ $= 1.2890$ $= 185,900$

$S_e = (W_s + W_{mg} + W_{hw} + W_{gi}) \times r_n$ $(3904 + 536 + 6455 + 1984) \times .95$ $(W_g + W_{gy}) (r_{wg} \times h_{wg} \times z_{wg} \times w_{yg})$ $[6956 + 6579 + (12425 - 6579)/2] \times 1 \times 1 \times 1 \times 1.1$ $W_i \times r_{wi} \times h_{wi}$ $100,305 \times .95 \times 1$ $W_y \times r_{wy} \times h_{wy} \times z_{wy} \times w_{yy}$ $34109 \times 1 \times 1 \times 1 \times 1.1$ $S_e \text{ (total)}$	$= 11,285$ $= 29,105$ $= 95,290$ $= 37,520$ $= 173,200$

$V_e = N_e \times u_v/r_u \times \sqrt{S_f/S_e} \times v_y \times v_r$ $19520 \times 1/1 \times .8083 \times .9 \times 1$ $v_e = 1 - V_e/S_e = 1-.0798$ $M_e = (N_e + 12J + W_i) \times m_{yf}/N_e$ $[9520 + 12(1105 + 722 + 390) + 100305] \times 1.1/19520$ $m_a = M_a - (1 - r_m \times h_m)(M_a - 1)$ $1.289 - (1 - .95 \times 1)(1.289)$ $P_e = S_e \times m \times l \times e \times t \times o \times b \times u_s \times r_u \times h_u \times z_u \times v_e$ $173,200 \times 1.2745 \times 1 \times 1 \times 1 \times 1 \times 1 \times 1 \times 1 \times .9202$ $P_e/P_f = 1.09$	$= 8.2516$ $= 1.2745$ $= 203,128$

Effects of Surprise

$$M_a = \sqrt{1.6615 \times 3} = 2.2326 \quad m_a = 2.1710$$

$$v_f = 1 - (2 \times .1094) = 0.7812 \quad v_e = 1 - (.6 \times .0798) = .9521$$

$$P_f = 163,063 \quad P_e = 364.655$$

$$P_f/P_e = 0.4472 \quad P_e/P_e = 2.2363$$

Result Calculations

$$Q = 45, D_f = 8.8, C_{sf} = 3,000, C_{se} = 500$$

$$E_{fsp} = \sqrt{(S_e \times u_{se})/(S_f \times u_{sf}) \times (4Q + D_e)/3D_f}$$

$$\sqrt{1.5305 \times 1.55 \times (4 \times 45 + 8.8)/3 \times 8.8} = -2.5538$$

$$E_{fcas} = v_e^2 \left[\sqrt{(C_{se} \times u_{sf}/S_e)/(C_{sf} \times u_{se}/S_f)} - \sqrt{100C_{sf}/N_f} \right]$$

$$.9065 \left[\sqrt{500 \times .6534 \times 1.55/3000} - \sqrt{30000/19500} \right] = -3.1865$$

$$R_f = M_F + E_{fsp} + E_{fcas} = 2-2.55-3.19 = -3.7403$$

$$R_f - R_e = -15.93$$

$$E_{esp} = \sqrt{(S_f \times u_{sf})/(S_e \times u_{se}) \times (4Q + D_f)/3D_e}$$

$$\sqrt{.6534 \times 1.55 \times (4 \times 45 + 8.8)/3 \times 8.8} = 2.666$$

$$E_{ecac} = v_f^2 \left[\sqrt{(C_{sf} \times u_{se}/S_f)/(C_{se} \times u_{sf}/S_e)} - \sqrt{100C_{se}/N_e} \right]$$

$$.6103 \left[\sqrt{3000 \times 1.5305/(1.55 \times 500)} - \sqrt{500 \times 19520} \right] = .5224$$

$$R_e = M_E + E_{esp} + E_{ecac} = 9 + 2.67 + .52 = 12.19$$

$$R_e - R_f = +15.93$$

Figure 18. PRELIMINARY 1967 ARAB-ISRAELI WAR ANALYSIS

Engagement	N_a/N_i	Fire-power	P/P	Surprise	P/P (S&D)	R - R	Effect P/P	Arab CEV	Israeli CEV	Average
1. Rafa	1.00	0.69	0.92	0.49	0.45	-15.93	0.24	0.53	1.87	
2. Abu Ageila	0.96	1.06	1.80	0.32	0.58	-11.58	0.30	0.52	1.92	
3. Gaza	1.44	0.96	1.41	0.51	0.72	-14.29	0.26	0.36	2.77	2.35
5. Bir Lahfan	0.96	0.53	0.65	.	0.65	-16.85	0.23	0.35	2.83	
11. Jerusalem	0.49	0.42	0.71	0.84	0.60	-8.70	0.36	0.60	1.67	
12. Jenin	0.57	0.34	0.51	0.84	0.43	-9.91	0.34	0.67	1.49	
13. Kabatiya	0.77	0.67	0.83	.	0.83	-6.90	0.42	0.51	1.98	
14. Zababida	1.02	0.57	0.80	.	0.80	-7.98	0.38	0.47	2.11	1.81
21. Qala	1.09	0.43	0.56	.	0.56	-17.87	0.22	0.39	2.56	
22. Tel Fahar	1.11	0.55	0.75	.	0.75	-17.36	0.22	0.29	3.45	
23. Rawiya	1.00	1.77	3.69	0.42	1.55	-12.04	0.29	0.19	5.34	
24. Banyas M.	0.78	0.60	0.85	.	0.85	-15.78	0.24	0.28	3.53	3.71

Figure 19. 1967 ARAB-ISRAELI WAR ANALYSIS—REFINED

Engagement	N_a/N_i	Fire-power	Arab Set-Piece Factor	P/P	Surprise	Disruption	P/P (S&D)	R - R	Effect P/P	CEVs Arab	CEVs Israeli	Average
1. Rafa	1.00	0.69	1.3	1.20	0.37	.	0.44	-15.93	0.24	0.54	1.84	
2. Abu Ageila	0.96	1.06	1.3	2.34	0.24	.	0.56	-11.58	0.30	0.53	1.87	
3. Gaza	1.44	0.96	1.3	1.48	0.38	0.31	0.51	-14.29	0.26	0.51	1.96	
5. Bir Lahfan	0.96	0.53	.	0.65	.	0.77	0.50	-16.85	0.23	0.46	2.18	1.96
										1st half average: 1.86 2d half average: 2.07		
11. Jerusalem	0.49	0.42	1.3	0.92	0.67	.	0.61	-8.70	0.36	0.59	1.69	
12. Jenin	0.57	0.34	1.3	0.66	0.63	.	0.42	-9.91	0.34	0.81	1.24	
13. Kabatiya	0.77	0.67	.	0.67	.	0.74	0.50	-6.90	0.42	0.57	1.76	
14. Zababida	1.02	0.57	.	0.80	.	0.87	0.70	-7.98	0.38	0.54	1.84	1.63
										1st half average: 1.47 2d half average: 1.76		
21. Qala	1.09	0.43	1.3	0.73	.	.	0.73	-17.87	0.22	0.30	3.34	
22. Tel Fahar	1.11	0.55	1.3	0.98	.	.	0.98	-17.36	0.22	0.23	4.38	
23. Rawiya	1.00	1.77	1.3	4.75	0.32	.	1.53	-12.04	0.29	0.19	5.28	
24. Banyas M.	0.78	0.60	.	0.85	.	.	0.85	-15.78	0.24	0.28	3.53	4.13
										1st half average: 3.86 2d half average: 4.41		

COMBAT PERFORMANCE IN THE 1973 WAR

THE DATA

Figure 20 is a summary of the major statistical ground data of the 1973 "October War," including overall strengths and losses of personnel and selected items of equipment for all major participants. Figure 21 provides comparable air strength and loss data. Figures 22, 23, and 24 present more detailed listings of the principal varieties of ground weapons and combat equipment estimated to be on hand in the Israeli, Egyptian, and Syrian armies as of 6 October 1973, showing presumed allocations to major combat formations, such as divisions and brigades.

Figure 25 is a listing of all major engagements on the Suez-Sinai and Golan Fronts from October 6 through 25. Figure 26 is an estimated breakdown of the presumed total of Israeli and Egyptian casualties on that front, with allocations to days and engagements based upon professional historical and military judgment in consideration of the detailed HERO narrative of operations cited under "Data Sources" in the Introduction to this report. Figure 27 is a comparable breakdown of presumed Israeli and Egyptian tank losses on the Suez-Sinai front, by day and by engagement. Figure 28 is a comparable breakdown of estimated direct air support allocations by the Israeli and Egyptian air forces, also related to engagements and dates. Figure 29 is a listing of engagements on the Golan Front. Figures 30, 31, and 32 give comparable breakdowns of estimated casualties, tank losses and direct air support sorties on the Golan Front.

As in the case of analysis of the 1967 War data, available resources permitted analyses of only twelve engagements on the Suez-Sinai Front and four engagements on the Golan front. This was a total of six more 1973 War engagements than provided for in the Task Order, or a total of eight more engagements overall than provided for in the Task Order.

DATA ANALYSIS

Figure 33, "Preliminary 1973 Arab-Israeli War Analysis," provides the same kind of overall summary of this study's quantitative analysis of the 1973 war as is found in Figure 18 for the 1967 War analyses. Figure 34 provides a further refinement of the quantitative analysis after application to the 1973 War data of the same three hypotheses that were reflected in Figure 19 for the 1967 War.

As with the 1967 War, the refined analysis shown in Figure 26 shows remarkably consistent values in relative combat effectiveness of the opponents in each of the two sets of data: that for the Suez-Sinai front, and that for the Golan front. It shows that the Israeli combat effectiveness superiority over the Egyptians was on the average 116%, or a CEV of 2.16; Israeli superiority over the Syrians was 175% or a CEV of 2.75.

A normalized comparison, similar to that for the 1967 War, is shown below:

Israelis	2.75	(2.16)
Egyptians	1.27	(1.00)
Syrians	1.00	

CAMPAIGN ANALYSES

In order to seek possible effects of high command performance, and of airpower, on the overall campaign results and on calculated CEVs—as opposed to the individual engagement results—QJM analyses were performed on the overall campaign data and results for the three 1967 War campaigns and the two 1973 War campaigns. The results of these analyses are summarized in Figure 35.

Figure 20-A. ESTIMATED GROUND STRENGTHS, OCTOBER 1973

	Israel	Total Arab Committed	Egypt	Syria	Iraq Committed	Jordan Committed	Other Arabs	Iraq Total	Jordan Total	Total Arab Potential
Available Army Manpower ¹	310,000	505,000	315,000	140,000	20,000	5,000	25,000	95,000	75,000	650,000
Tank/Armored Divisions	7	5	2	2	1	..	..	2	2	8
Infantry/Mechanized Divs	..	11	8	3	..	..	..	4	3	18
Separate Brigades	18	47	20	21	..	1	5	?	?	46
Medium Tanks	2,000 ²	4,841	2,200 ⁵	1,820 ⁹	300	150	371	1,200	540	6,131
APCs	4,000 ³	4,320	2,400	1,300	300	200	120	1,500	550	5,870
Artillery (over 100mm)	570	2,055	1,210	655	54	36	100	600	320	2,885
Multiple Rocket Launchers	..	90	70	20	?	..	..	?	..	90
Mortars (over 100mm)	375	650+	350	300	?	?	?	?	?	650+
SSM Launchers	..	42	30	12	..	..	..	?	..	42
SAM Launchers	75	1,280	880 ⁶	360 ¹⁰	20	..	20	?	..	1,280
Strella	..	3,000	2,000	1,000	?	..	?	?	..	3,000
AA Guns	1,000	3,650+	2,750 ⁷	1,900 ¹¹	?	..	?	?	?	3,650+
AT Missiles	280 ⁴	1,200	850 ⁸	350 ¹²	?	..	..	?	..	1,200
AT Rockets	650	5,300+	2,500	2,800	?	?	?	?	?	5,300+
AT Guns	..	2,200+	1,300	900	?	?	?	?	?	2,200+

Notes: ¹Only field army and direct support manpower; for instance, total Israeli mobilized strength was over 350,000, Egyptian over 1,000,000.

²Includes 150 captured T-54/55, modified.

³Includes 3,500+ half-tracks, 500 M-113.

⁴Includes SS-10 and SS-11, apparently not used.

⁵Includes T-62.

⁶Includes 80 SA-6.

⁷Includes 150 ZSU-23-4.

⁸Mostly Sagger, some Snapper.

⁹Includes T-62.

¹⁰Includes 60 SA-6.

¹¹Includes 100 ZSU-23-4.

¹²Mostly Sagger, some Snapper.

Figure 20-B. ESTIMATED LOSSES, OCTOBER 1973

	Israel	Arab Total	Egypt	Syria	Jordan	Iraq	Other Arabs
Personnel							
Killed	2,838*	8,528	5,000	3,100	28	300	100
Wounded	8,800*	19,549	12,000	6,000	49	1,000	500
Prisoners or Missing	508	8,551	8,031	500	--	20	?
Tanks**	840	2,554	1,100	1,200	54	200	?
APCs	400	850+	450	400	--	?	?
Artillery Pieces	?	550+	300	250	--	?	?
SAM Batteries	--	47	44	3	--	--	?
Aircraft	102	360	223	117	--	20	?
Helicopters	?	55	42	13	--	?	?
Naval Vessels	1	15	10	5	--	--	--

*About 10% has been added to officially reported Israeli casualties to represent approximately the wounded who died of their injuries, and the fact that official Israeli figures apparently do not include those wounded not evacuated from aid stations and field hospitals.

**Tanks destroyed or put out of action for one or more days. For instance, the Israelis seem to have repaired and returned to operation about 400 of the tank losses shown here. They also recovered about 300 repairable Arab tanks.

Figure 21-A. AIR FORCE STRENGTHS, OCTOBER 1973

	A R A B S							I S R A E L I S	
	Egypt		Syria		Iraq	Other Arabs	Total Arab	Inventory	Resupply*
	Inventory	Resupply*	Inventory	Resupply*			Inventory		
Fighters									
MiG-21	160	..	110	..	18	23	311	150	20
MiG-19	60	..	..	..	..	..	60	140	36
MiG-17	200	..	120	..	7	24	351	50	
Su-7	130	..	45	..	32	12	219	12	
Hunter	..	..	..	..	16	5	21		
Mirage	..	..	..	..	..	28	28		
Total Fighters	550	93	275	113	73	92	990	352	56
Bombers									
Tu-16	18	..	..	..	..	..	18	8	
Il-28	30	..	..	..	..	..	30		
Total Bombers	48						48	8	?
Total Combat	598		275		73	92	1,038	360	
Transports									
An-12	30	..	..	..	..	..	30	6	
Il-14	40	..	12	..	..	..	52	12	
Il-18	..	..	4	..	..	..	4	10	
Total Transports	70		16				86	30	?
Helicopters									
Mi-6	12	..	6	..	..	..	18	8	
Mi-8	70	..	30	..	..	..	1	12	
Total Helicopters	82	70	36	12		12	130	30	?
Total Non-combat	152		52			12	216	116	?
Total Air Inventory	750		327		73	104	1,254	476	
Losses	265		131		21	30	447	109	
Resupply*	163		125				288	56+	
Total At End of War	648		321		52	74	1,095	423+	
Mandpower	23,000		9,000		?	?	32,000+	17,000	

*October 9-23, inclusive.

Figure 21-B. ESTIMATED AIR LOSSES, OCTOBER 1973

	Egypt	Syria	Iraq	Other Arabs	Arab Total	Israel
A. By Type						
Fighter	222	117	21	30	390	103
Bomber	1	..	..	..	1	..
Transport	..	1	..	..	1	..
Helicopter	42	13	..	..	55	6
Totals	265	131	21	30	447	109
B. By Cause						
Air-to-Air					287	21
To SAM					17	40
To AAA					19	31
Misc or Unknown					66	15
Friendly Forces					58	2
Totals					447	109
C. Damage						
Damaged					125	236
Repaired in One Week					?	215

Figure 22. ESTIMATED ISRAELI ARMAMENT SUMMARIES, 1973

	Inf Bde	Meczd Bde	Armd Bde	Armd Rgt	Arty Rgt	1/12 Div 1/36 Bde Misc Units	30 Arty Rgts	5 Armd Rgts	16 Inf/Para Bde	11 Meczd Bde	10 Armd Bde	Totals
Personnel	4,300	4,000	3,600	1,700	1,000	30,000	30,000	8,500	68,800	44,000	36,000	217,300
Pistol, Cal .45	430	400	360	170	100	3,000	3,000	850	6,880	4,400	3,600	21,730
Rifle (Galil 5.56 FN)	3,870	3,600	3,240	1,530	900	27,000	27,000	7,650	61,920	39,600	32,400	195,570
Machine Gun, lt, Cal .30	120	80	40	30	10	300	300	150	1,920	880	400	3,950
Machine Gun, hvy, Cal .50	80	60	40	30	20	500	600	150	1,280	660	400	3,590
Mortar, 81mm	20	10	..	..	..	..	..	..	320	110	..	430
Mortar, 4.2", 107mm	12	8	..	..	..	..	..	..	192	88	..	280
Mortar, 120mm	..	..	..	..	..	..	(4) 96	..	64	44	..	204
Mortar, 160mm	..	..	..	..	?	..	?	..	..	..	..	?
APC M-113	10	20	10	5	..	..	..	25	160	220	100	505
Halftrack M3	50	200	20	10	3	151	90	30	800	2,200	200	3,471
Bazooka/LAW	20	10	..	..	5	55	150	..	320	110	..	635
RECG, 84mm	..	..	..	..	..	..	..	..	..	..	..	..
RRSP, 106mm	6	..	..	..	..	96	..	..	96	..	..	192
AA, lt, 20mm	16	12	12	6	2	172	60	30	256	132	120	770
AA, lt, 40mm	..	..	..	..	4	92	120	..	..	..	..	212
SAM Hawk	..	..	..	..	..	75	..	..	..	..	..	75
How, SP, 105mm	..	..	..	..	..	..	(9) 216	..	..	..	..	216
How, SP, 155mm	..	..	..	..	..	..	(9) 216	..	..	..	..	216
Gun, SP, 155mm	..	..	..	..	..	..	(4) 96	..	..	..	..	96
Gun, SP, 175mm	..	..	..	..	..	..	(3) 72	..	..	..	..	72
How, SP, 8"	..	..	..	..	..	..	(1) 12	..	..	..	..	12
Tanks	20	48	96	48	..	..	..	240	320	528	960	2,048
Tanks, M48 (90mm)	..	..	..	..	..	..	..	..	..	..	..	100
Tanks, M48 (105mm)	..	..	..	..	..	..	..	..	..	..	..	600
Tanks, Centurion	..	..	..	..	..	..	..	..	..	..	..	600
Tanks, M60	..	..	..	..	..	..	..	..	..	..	..	400
Tanks, T54/55 (105mm)	..	..	..	..	..	..	..	..	..	..	..	200
Tanks, M4 (105mm)	..	..	..	..	..	..	..	..	..	..	..	148
APC, M113	10	20	10	5	..	..	..	25	160	220	100	505
Halftracks	50	200	20	10	3	151	90	50	800	2,200	200	3,491
Trucks	150	150	150	75	100	3,000	3,000	375	2,400	1,650	1,500	11,925
SP Mts	38	38	38	19	25	300	750	95	608	418	380	2,551

Figure 23. ESTIMATED EGYPTIAN ARMAMENT SUMMARIES, 1973

	Inf Div	Armd Div	Meczd Div	Inf Bde	Armd Bde	1/10 Div Army Spt Units	5 Inf Divs	2 Armd Divs	3 Meczd Divs	12 Inf Bdes	8 Armd Bdes	Totals
Personnel	10,000	10,000	12,000	4,000	3,500	64,000	50,000	20,000	36,000	48,000	28,000	246,000
Pistol, 9mm Beretta	1,000	1,000	1,200	400	350	6,400	5,000	2,000	3,600	4,800	2,800	24,600
Rifle (A-47 AKM)	9,000	9,000	10,800	3,600	3,150	57,600	45,000	18,000	32,400	43,200	25,200	221,400
MG, lt, SGM 7.62	360	270	360	120	85	1,800	1,800	540	1,080	1,440	680	7,340
MG, hvy, DK 12.7	240	160	240	80	55	1,200	1,200	320	720	960	440	4,840
Mortar, 82mm	50	..	50	16	..	..	250	..	150	192	..	592
Mortar, 120mm	12	..	12	4	..	206	60	..	36	48	..	350
RPG-7, 82mm	100	20	100	30	6	100	500	40	300	360	48	1,348
Sagger	40	16	40	12	4	15	200	32	120	144	32	543
Inf RR, 82mm	20	..	20	6	..	..	100	..	60	72	..	232
Inf RR, 107mm	10	..	10	3	..	..	50	..	30	36	..	116
SPG-9 RR, 73mm	30	24	30	10	8	50	150	48	90	120	64	522
GAT D-48, 85mm	16	..	16	..	..	..	80	..	48	..	..	128
GAT M-55, 100mm	8	12	8	..	..	210	40	24	24	..	..	298
AAMG ZPU-4	9	9	9	3	3	300	45	18	27	36	24	450
AAMG ZU-23	9	9	9	3	3	300	45	18	27	36	24	450
AAMG ZSU-23-4	12	12	12	4	4	100	60	24	36	48	32	300
AAMG S-60, 57mm	12	12	12	4	4	350	60	24	36	48	32	550
MRL, 122mm	12	4	12	..	..	20	60	8	36	..	..	124
How, 122mm	54	36	54	12	..	224	270	72	162	144	..	872
Gun How, 122mm	..	..	..	..	..	84	60	..	36	..	..	180
Gun How, 152mm	12	..	12	..	..	..	..	..	..	..	..	36
Gun, 180mm	..	..	..	..	..	36	..	..	..	..	..	20/10
Scud/Frog	..	..	..	..	..	20/10	..	..	..	..	..	20/10
Grail SA-7	50	50	50	16	16	100	250	100	150	192	128	920
SA 2/3	..	..	..	..	..	800	..	..	..	..	..	800
SA-6	..	..	..	..	..	80	..	..	..	..	..	80
Gun AT-Su-100, SP	12	..	12	4	..	..	60	..	36	48	..	144
Tank, lt, PT76	..	30	10	..	10	..	..	60	30	..	80	170
Tank, med, T54/55	20	260	80	10	80	..	100	520	240	120	640	1,620
Tank, hvy, T62	..	70	30	..	30	..	..	140	90	..	240	470
APC BTR60	55	..	110	12	..	71	275	..	330	144	..	820
APC BTR50	..	24	120	..	12	46	..	48	360	..	96	550
APC BRDM1	36	12	120	6	6	36	180	24	360	72	48	720
APC BRDM2	3	..	6	1	..	..	15	..	18	12	..	45
APC BMP	2	2	4	..	1	10	10	4	12	..	8	44
BMP/Sagger	3	..	6	1	..	..	15	..	18	12	..	45
Truck	800	600	800	250	200	2,000	4,000	1,200	2,400	3,000	1,600	14,200
Motorcycle	60	50	60	20	20	100	300	100	180	240	160	1,080
SP Mounts	44	34	44	14	10	200	220	68	132	168	80	868

Figure 24. ESTIMATED SYRIAN ARMAMENT SUMMARIES, 1973*

	Inf Div	Armd Div	Inf Bde	Armd Bde	1/10 Div Army Spt Units	1 Meczd Div	2 Inf Divs	2 Armd Divs	11 Sep Inf Bdes	10 Sep Armd Bdes	Totals
Personnel	10,000	10,000	4,000	3,500	25,000	13,000	20,000	20,000	44,000	35,000	157,000
Pistol, Markarov	1,000	1,000	400	350	2,500	1,300	2,000	2,000	4,400	3,500	15,700
Rifle, AK-47	9,000	9,000	3,600	3,150	22,500	11,700	18,000	18,000	39,600	31,500	141,300
MG, lt, 7.62	300	200	90	80	100	300	600	400	990	800	3,190
Mg, hvy, 12.7	200	160	60	50	200	200	400	320	660	500	2,280
Mortar, 82mm	50	..	16	..	..	50	100	..	176	..	326
Mortar, 120mm	12	..	4	..	50	12	24	..	44	..	130
RPG-7, 82mm	100	30	30	10	350	120	200	60	330	100	1,160
Sagger	50	20	12	6	..	50	100	40	132	60	382
SPG-9, 73mm	60	24	20	8	30	60	120	48	220	80	558
GAT M-55, 100mm	24	12	..	..	150	24	48	24	..	..	246
AAMG ZPU-4	9	9	3	3	150	9	18	18	33	30	258
AAMG ZU-23	9	9	3	3	150	9	18	18	33	30	258
AAMG ZSU-23-4	12	12	4	4	40	12	24	24	44	40	184
AAMG S-60, 57mm	12	12	4	4	150	12	24	24	44	40	294
MRL, 122mm	12	..	..	..	10	12	24	..	..	..	46
How, 122mm	54	36	12	12	50	54	110	72	132	120	538
Gun How, 152mm	12	..	..	..	24	12	24	..	..	..	60
Gun, 180mm	..	..	..	..	12	..	..	..	..	..	12
Frog	..	..	..	..	..	12	..	..	..	..	12
Grail SA-7	36	36	12	12	100	36	72	72	132	120	532
SA 2/3	..	..	..	..	300	..	..	..	..	..	300
SA-6	..	..	..	..	60	..	..	..	..	..	60
GAT SU-100	12	..	4	..	..	12	24	..	44	..	80
Tank, lt, PT76	..	30	..	10	..	10	..	60	..	100	170
Tank, med, T54/55	..	180	..	60	..	60	..	360	..	580	1,000
Tank, med, T62	..	90	..	30	..	20	..	180	..	250	450
Tank, hvy, JS 111/110	..	..	..	..	..	30	..	..	..	..	30
Tank, med, T-34	20	..	10	..	..	..	40	..	110	70	220
APC BTR60	50	20	10	10	150	200	100	40	110	100	700
APC BRDM1	30	10	5	5	100	100	60	20	55	50	385
APC BRDM2	15	5	4	4	10	50	30	10	44	40	184
APC BMP	20	20	5	5	45	20	40	40	55	50	250
Trucks	800	600	250	200	500	800	1,600	1,200	2,750	2,000	8,850
Motorcycles	50	40	20	20	20	50	100	80	220	200	670
SP Mounts	44	34	14	10	100	44	88	68	154	100	554

*Plus 1 Moroccan infantry brigade, 1 Jordanian armored brigade, and 1 Iraqi armored division.

Figure 25. SINAI FRONT ENGAGEMENTS, OCTOBER 1973

Eng No	Date	Engagement Designation	Egyptian Forces	Israeli Forces
73- 1	Oct 6	Suez Canal Assault (N)	Second Army	Elements 1 armd & 1 inf bde
73- 2	6	Suez Canal Assault (S)	Third Army	Elements 1 armd & 1 Inf bde
73- 3	7	Second Army Buildup	Second Army	Mendler Div(-) & elms Adan & Sharon
73- 4	7	Third Army Buildup	Third Army	Mendler Div(-)
73- 5	8	Kantara-Firdan	Second Army	Adan & Sharon Divs(-)
73- 6	14	Egypt Offensive (N)	Second Army	Sassoon, Adan & Sharon Divs
73- 7	14	Egypt Offensive (SN)	Third Army	Magen(+)
73- 8	15/16	Deversoir (Chinese Farm I)	1/2 16 Div, 1/2 21 Div	Sharon
73- 9	16/17	Chinese Farm (II)	1/2 16 Div, 1/2 21 Div(+)	Adan(+)
73-10	18	Deversoir West	Second Army elms	Adan(+)
73-11	19-21	Jebel Geneifa	Third Army elms	Adan & Magen
73-12	19-22	Ismailia	Second Army elms	Sharon
73-13	21-22	Adabiya	Third Army elms	Magen
73-14	22	Shallufa I	Third Army elms	Adan
73-15	23/24	Suez	Third Army elms	Adan
73-16	23/24	Shallufa II	Third Army elms	Adan(-)

Figure 26. ESTIMATED ALLOCATION OF BATTLE CASUALTIES, SINAI FRONT, OCTOBER 6-24, 1973, INCLUSIVE

Date	Engagements						Egyptian			Israeli		
	Egypt	Israel	Egypt	Israel	Egypt	Israel	Daily Eng	Misc	Cumulative	Daily Eng	Misc	Cumulative
Oct 6	(1) 300	(1) 125	(2) 200	(2) 75	..	..	500	..	500	200	200	400
7	(3) 350	(3) 400	(4) 250	(4) 300	..	..	600	..	1,100	700	100	1,200
8	(5) 1,000	(5) 1,000	..	..	..	..	1,000	100	2,200	1,000	200	2,400
9	..	..	..	..	..	..	..	500	2,700	..	200	2,600
10	..	..	..	..	..	..	..	300	3,000	..	100	2,700
11	..	..	..	..	..	..	..	300	3,300	..	100	2,800
12	..	..	..	..	..	..	..	300	3,600	..	100	2,900
13	..	..	..	..	..	..	..	200	3,800	..	100	3,000
14	(6) 1,600	(6) 150	(7) 2,000	(7) 250	..	..	3,600	100	7,500	400	150	3,500
15	(8) 700	(8) 300	..	..	..	..	700	..	7,700	..	150	3,600
16	(9) 900	(9) 400	..	..	..	..	900	200	8,400	300	..	3,900
17	(9) 900	(9) 400	..	..	..	..	900	200	9,500	400	100	4,400
18	(10) 900	(10) 300	..	..	..	..	900	200	10,600	400	100	4,900
19	(12) 375	(12) 100	(11) 334	(11) 100	..	..	709	191	11,700	300	100	5,300
20	(12) 375	(12) 100	(11) 333	(11) 100	..	..	708	192	12,600	200	100	5,600
21	(12) 375	(12) 100	(11) 333	(11) 100	..	..	708	192	13,500	200	100	5,900
	..	..	..	..	(13) 200	(13) 50	200	..	14,400	200	100	6,200
22	(12) 375	(12) 100	(14) 1,500	(14) 150	..	..	1,875	725	14,600	50	..	6,250
23	(15) 400	(15) 150	(16) 500	(16) 50	..	..	900	2,300	17,200	250	100	6,600
24	(15) 400	(15) 150	(16) 500	(16) 50	..	..	900	2,300	20,400	200	50	6,850
									23,600	200	50	7,100

Figure 27. ESTIMATED ALLOCATION OF TANK LOSSES, SINAI FRONT, OCTOBER 6-24, 1973, INCLUSIVE

Date	Engagements				Egypt				Israel			
	Egypt	Israel	Egypt	Israel	Daily Loss	Cum Loss	Daily Return	Cum Net Loss	Daily Loss	Cum Loss	Daily Return	Cum Net Loss
Oct 6	(1) 10	(1) 50	(2) 30	(2) 50	40	40	..	40	100	100	..	100
7	(3) 10	(3) 40	(4) 10	(4) 50	20	60	2	58	90	190	10	180
8	(5) 10	(5) 75	..	..	10	70	4	64	75	265	19	236
9	25	10	..	..	25	95	5	84	10	275	26	220
10	25	10	..	..	25	120	7	102	10	285	28	202
11	25	10	..	..	25	145	11	116	10	295	28	184
12	25	10	..	..	25	170	8	133	10	305	20	174
13	20	10	..	..	20	190	10	143	10	315	12	172
14	(6) 110	(6) 15	(6) 150	(6) 25	260	450	11	392	40	355	5	207
15	10	10	..	..	10	460	26	376	10	365	8	209
	(8) 50	(8) 30	..	..	50	510	..	426	30	395	8	231
16	(9) 90	(9) 16	..	..	90	600	24	492	16	411	10	237
17	(9) 150	(9) 16	..	..	150	750	34	608	16	427	11	242
18	(10) 70	(10) 15	..	..	70	820	38	640	15	442	11	246
19	(12) 30	(12) 15	(11) 30	(11) 15	60	880	40	660	30	472	8	268
20	(12) 30	(12) 8	(11) 30	(11) 8	60	940	25	695	16	488	11	273
21	(12) 30	(12) 8	(11) 30	(11) 8	60	1,000	25	730	16	504	9	280
	..	..	(13) 20	(13) 10	20	1,020	22	728	10	514	10	280
22	(12) 30	(12) 10	(14) 30	(14) 10	60	1,080	17	771	20	534	8	292
23	(15) 25	(15) 12	(16) 35	(16) 12	60	1,140	17	814	24	558	9	307
24	(15) 25	(15) 12	(16) 35	(16) 12	60	1,200	17	857	24	582	8	323
							57	800			32	291

Figure 28. ESTIMATED CLOSE AIR SUPPORT FIGHTER-BOMBER SORTIES
SUEZ-SINAI FRONT, OCTOBER 6-24, 1973

Date	Available This Front for CAS		Engagements					
	Egypt	Israel*	Egypt	Israel	Egypt	Israel	Egypt	Israel
Oct. 6	208	141	(1) 104	(1) 70	(2) 104	(2) 70	..	..
7	201	135	(3) 100	(3) 67	(4) 100	(4) 67	..	..
8	200	132	(5) 100	(5) 66	..	..	..	..
9	195	66**	..	..	..	..	..	..
10	191	65**	..	..	..	..	..	..
11	187	62**	..	..	..	..	..	..
12	180	60**	..	..	..	..	..	..
13	179	60**	..	..	..	..	..	..
14	176	289	(6) 44	(6) 72	(7) 44	(7) 72	..	..
15	175	116**	..	..	..	..	..	..
16	167	229	(9) 167	(9) 229	..	..	..	..
17	160	305	(9) 160	(9) 305	..	..	..	..
18	159	305	(10) 159	(10) 305	..	..	..	..
19	148	240	(12) 74	(12) 120	(11) 74	(11) 120	..	..
20	131	302	(12) 115	(12) 151	(11) 115	(11) 151	..	..
21	123	239	(12) 61	(12) 119	(11) 61	(11) 119	..	..
22	113	248	(12) 38	(12) 83	(13) 37	(13) 82	(14) 37	(14) 82
23	112	309	(15) 56	(15) 154	(16) 56	(16) 154	..	..
24	115	309	(15) 57	(15) 154	(16) 57	(16) 154	..	..

*October 6-13, inclusive, one-third Israeli air effort allocated to this front, two-thirds to Golan; thereafter two-thirds to this front, one-third to Golan.

**On dates where no engagements are shown on this front, half available Israeli CAS sorties are allocated to other front, and vice versa.

Figure 29. GOLAN FRONT ENGAGEMENTS, OCTOBER 1973

Eng No	Date	Engagement Designation	Arab Forces	Israeli Forces
73-21	Oct 6/7	Ahmadiye	7 Inf Div(+), 1/2 9 Inf Div	7 Armd Bde, 1/2 Golani Bde
73-22	6/7	Rafid	5 Meczd Div(+), 1/2 9 Inf Div	188 Armd Bde, 1/2 Golani Bde
73-23	7-9	Mt. Hermonit	7 Inf Div(+), 1/2 9 Inf Div, 3d Tank Div	7 Armd Bde(-), 1/3 Golani Bde
73-24	7/8	Nafekh	5 Meczd Div, 1/2 9 Inf Div, 1st Tank Div	Laner & Peled Divs (-)
73-25	8	Mt Hermon I	Moroccan Bde(+)	Golani Bde(-)
73-26	8/9	Hushniya	5 Meczd, 1/2 9 Inf, 1st Tank	Laner & Peled
73-27	10-12	Saassa Offensive	1, 3, 5, 7, 9 Divs(+)	Eytan & Laner
73-28	13	Tel el Hara	Iraqi 3d Tank Div	Laner
73-29	15	Kfar Sharms	Iraqi 3d Tank Div(+)	Laner
73-30	16	Naba	Jordanian 40 Bde(+)	Laner(-)
73-31	19	Arab Counteroffensive	Iraqi 3d, Jordanian 40(+)	Peled
73-32	21	Mt Hermon II	Moroccan Bde(+)	Golani Bde
73-33	22	Mt Hermon III	Moroccan Bde(+)	Golani Bde(+)

Figure 30. ESTIMATED ALLOCATION OF BATTLE CASUALTIES, GOLAN FRONT, OCTOBER 6-22, 1973, INCLUSIVE

Date	Engagements						Arab			Israeli		
	Arab	Israel	Arab	Israel	Arab	Israel	Daily		Cumu- lative	Daily		Cumu- lative
							Eng	Misc		Eng	Misc	
Oct 6	(21)200	(21)100	(22)400	(22)300	..	..	600	..	600	400	..	400
	..	..	(22)400	(22)300	..	..	400	..	1,000	300	..	700
7	(21)200	(21)100	(24)300	(24)200	..	..	500	..	1,500	300	..	1,000
	(23)900	(23)350	..	..	..	..	900	..	2,400	350	..	1,350
8	..	..	(24)300	(24)200	(25)100	(25)100	400	200	3,000	300	100	1,750
	(23)900	(23)350	(26)500	(26)200	..	..	1,400	..	4,400	550	..	2,300
9	..	..	(26)500	(26)200	..	..	500	200	5,100	200	100	2,600
10	(27)600	(27)300	..	..	..	..	600	200	5,800	300	100	3,000
11	(27)500	(27)200	..	..	..	..	500	200	6,500	200	100	3,300
12	(27)500	(27)100	..	..	..	..	500	200	7,200	100	100	3,500
13	(28)600	(28)150	..	..	..	..	600	200	8,000	150	100	3,700
14	..	..	..	..	..	..	..	200	8,200	..	100	3,800
15	(29)600	(29)100	..	..	..	..	600	200	9,000	100	100	4,000
16	(30)400	(30)100	..	..	..	..	400	200	9,600	100	50	4,150
17	..	..	..	..	..	..	..	200	9,800	..	50	4,200
18	..	..	..	..	..	..	..	200	10,000	..	50	4,250
19	(31)600	(31)200	..	..	..	..	600	200	10,800	200	100	4,550
20	..	..	..	..	..	..	..	200	11,000	..	50	4,600
21	(32)200	(32)150	..	..	..	..	200	150	11,350	150	50	4,800
22	(33)200	(33)200	..	..	..	..	200	100	11,650	200	50	5,050

Figure 31. ESTIMATED ALLOCATION OF TANK LOSSES, GOLAN FRONT, OCTOBER 6-22, 1973

Date	Engagement						Arab				Israel			
	Arab	Israel	Arab	Israel	Arab	Israel	Daily Loss	Cum Loss	Daily Return	Cum Net Loss	Daily Loss	Cum Loss	Daily Return	Cum Net Loss
Oct 6	(21) 75	(21) 8	(22) 50	(22) 35	..	..	125	125	..	..	43	43	..	..
	..	..	50	35	..	..	50	175	8	167	35	78	5	73
7	(21) 75	(21) 8	(24) 38	(24) 8	..	..	113	288	12	268	16	94	8	81
	(23)105	(23) 25	..	..	..	..	105	393	20	353	25	119	9	97
8	..	..	(24) 38	(24) 8	(25) 0	(25) 0	38	431	25	366	8	127	12	93
	(23)105	(23) 25	(26) 75	(26) 15	..	..	180	611	30	516	40	167	12	121
9	..	..	(26)100	(26) 14	..	..	100	711	31	585	14	181	13	122
10	(27) 50	(27) 7	..	..	..	..	50	761	37	598	7	188	10	119
11	(27) 40	(27) 7	..	..	..	..	40	801	30	608	7	195	11	115
12	(27) 40	(27) 7	..	..	..	..	40	841	29	619	7	202	7	115
13	(28)100	(28) 7	..	..	..	..	100	941	26	693	7	209	9	113
14	25	3	12	..	..	..	37	978	23	700	3	212	3	113
15	(29) 60	(29) 7	12	..	..	..	72	1,050	16	749	7	219	3	117
16	(30) 66	(30) 10	12	..	..	..	78	1,128	19	802	10	229	3	124
17	..	..	20	3	..	..	20	1,148	20	802	3	232	3	124
18	..	..	18	3	..	..	18	1,166	20	820	3	235	3	124
19	(31)100	(31) 11	20	..	..	..	120	1,286	15	925	11	246	3	132
20	..	..	30	4	..	..	30	1,316	21	934	4	250	3	133
21	(32) 0	(32) 0	20	4	..	..	20	1,336	19	935	4	254	3	134
22	(33) 0	(33) 0	18	4	..	..	18	1,354	16	937	4	258	3	135
									34	903			6	129

Figure 32. ESTIMATED CLOSE AIR SUPPORT FIGHTER BOMBER SORTIES
GOLAN FRONT, OCTOBER 6-22, 1973

Date	Available This Front for CAS		Engagements					
	Arab	Israel*	Arab	Israel	Arab	Israel	Arab	Israel
Oct 6	143	281	(21) 71	(21)140	(22) 71	(22)140	..	..
7	139	269	(21) 69	(21)134	(24) 69	(24)134	..	..
8	132	264	(23) 66	(23)132	(24) 66	(24)132	..	..
9	128	349	(23) 64	(23)174	(26) 64	(26)174	..	..
10	128	325	(27)128	(27)325	..	..	..	..
11	117	310	(27)117	(27)310	..	..	..	..
12	113	300	(27)113	(27)300	..	..	..	..
13	103	299	(28)103	(28)299	..	..	..	..
14	100	58**	..	..	..	..	..	..
15	97	232	(29) 97	(29)232	..	..	..	..
16	140	115	(30)140	(30)115	..	..	..	..
17	87	61**	..	..	..	..	..	..
18	85	61**	..	..	..	..	..	..
19	87	120	(31) 87	(31)120	..	..	..	..
20	88	61**	..	..	..	..	..	..
21	85	119	(32) 85	(32)119	..	..	..	..
22	79	124	(33) 79	(33)124	..	..	..	..

*October 6-13, inclusive, two-thirds of Israeli air effort allocated to this front, one-third to Suez-Sinai; thereafter one-third to this front, two-thirds to Suez-Sinai.

**On dates when no engagements are shown on this front, half available Israeli CAS sorties are allocated to other front, and vice versa.

Figure 33. PRELIMINARY 1973 ARAB-ISRAELI WAR ANALYSIS

Engagement	N _a /N _i	Fire-power	P/P	Sur-prise	P/P (S&D)	R - R	Effect P/P	Arab CEV	Israeli CEV
1. Canal Crossing, N	7.68	4.07	1.01	2.57	2.60	6.03	2.21	0.85	1.18
2. Canal Crossing, S	7.92	4.76	1.29	2.40	3.10	7.27	2.45	0.79	1.27
3. Egypt Buildup, N	4.22	2.33	0.94	..	0.94	2.68	1.54	1.64	0.61
4. Egypt Buildup, S	3.90	2.42	0.99	..	0.99	2.92	1.58	1.59	0.63
5. Adan Counterattack	2.48	1.79	2.08	..	2.08	5.54	2.11	1.01	0.99
6. Egypt Offensive, N	1.98	1.41	0.71	..	0.71	-9.34	0.35	0.49	2.04
7. Egypt Offensive, S	2.19	1.64	0.93	..	0.93	-8.23	0.38	0.41	2.44
8. Op Gazelle (Canal)	1.20	0.93	1.31	0.86	1.13	-5.82	0.46	0.45	2.22
9. Chinese Farm	1.25	0.94	1.33	..	1.33	-6.50	0.43	0.30	3.09
10. Deversoir, West	0.95	0.92	1.49	..	1.49	-3.35	0.60	0.40	2.50
11. Geneifa	1.09	0.86	1.14	..	1.14	-7.75	0.39	0.39	2.92
12. Ismailia	1.40	1.09	1.45	..	1.45	-0.40	0.93	0.64	1.56
21. Ahmadiye	3.15	1.19	0.30	1.80	0.54	-6.39	0.44	0.81	1.23
22. Rafid	3.46	1.74	0.68	2.17	1.48	7.57	2.51	0.59	1.70
23. Mt. Hermonit	5.40	3.03	0.72	..	0.72	-4.46	0.53	1.36	0.73
24. Nafekh	1.18	1.01	1.75	..	1.75	-6.14	0.45	3.85	0.26

Figure 34. 1973 ARAB-ISRAELI WAR ANALYSIS—REFINED

Engagement	N _a /N _i	Fire-power	Arab Set-Piece Factor	P/P	Surprise	Disruption	P/P (S&D)	R - R	Effect P/P	CEVs		Average
										Arab	Israeli	
1. Canal Crossing, N	7.68	4.07	1.3	1.31	3.43	..	4.49	6.03	2.21	0.49	2.03	
2. Canal Crossing, S	7.92	4.76	1.3	1.68	3.20	..	5.38	7.27	2.45	0.45	2.20	
3. Egypt Buildup, N	4.22	2.33	1.3	1.22	..	2.61	3.18	2.68	1.54	0.49	2.06	
4. Egypt Buildup, S	3.90	2.42	1.3	1.29	..	2.47	3.19	2.92	1.58	0.50	2.02	
5. Adan Counterattack	2.48	1.79	1.3	2.33	..	1.81	4.22	5.54	2.11	0.50	2.00	
6. Egypt Offensive, N	1.98	1.41	..	0.71	..	..	0.71	-9.34	0.35	0.49	2.04	
7. Egypt Offensive, S	2.19	1.64	..	0.93	..	..	0.93	-8.23	0.38	0.41	2.44	
8. Op Gazelle (Canal)	1.20	0.93	..	1.31	0.70	..	0.92	-5.82	0.46	0.50	2.00	
9. Chinese Farm	1.25	0.94	..	1.33	..	0.80	1.06	-6.50	0.43	0.40	2.47	
10. Deversoir, West	0.95	0.92	..	1.49	..	0.90	1.34	-3.35	0.60	0.45	2.23	
11. Geneifa	1.09	0.86	..	1.14	..	..	1.14	-7.75	0.39	0.34	2.92	
12. Ismailia	1.40	1.09	..	1.45	..	..	1.45	-0.40	0.93	0.64	1.56	2.16
1st half average:											2.06	
2d half average:											2.27	
21. Ahmadiye	3.15	1.19	1.9	0.57	2.40	..	1.37	-6.32	0.44	0.32	3.11	
22. Rafid	3.46	1.74	1.9	1.29	2.90	..	3.74	7.57	2.51	0.67	1.49	
23. Mt. Hermonit	5.40	3.03	..	0.72	..	1.63	1.17	-4.38	0.53	0.45	2.21	
24. Nafekh	1.18	1.01	..	1.75	..	1.15	2.01	-5.14	0.49	0.24	4.17	2.75
1st half average:											2.30	
2d half average:											3.19	

Figure 35. COMPARATIVE CAMPAIGN ANALYSES, 1967, 1973

	N _a /N _i	Fire-power*	Calc P/P	Arab Set-Piece Factor	Revised Calc P/P	Surprise**	P/P (S&D)	R - R	Effect P/P	CEVs	
										Arab	Israeli
1967 - Sinai	1.82	1.37	2.28	1.1	2.46	0.39	0.96	-12.14	0.29	0.30	3.31
1967 - West Bank	0.95	0.65	1.14	1.1	1.25	0.64	0.80	-7.31	0.41	0.38	2.10
1967 - Golan	1.48	1.33	2.10	1.1	2.31	0.83***	1.92	-11.46	0.30	0.14	6.40
1973 - Sinai	2.37	3.03	1.41	1.1	1.55	1.04	1.61	-3.08	0.62	0.38	2.60
1973 - Golan	2.86	2.23	1.93	1.1	2.12	1.04	2.20	-4.65	0.52	0.23	4.23

*Includes actual daily air efforts of opposing sides, not air strengths prior to war.

**Assumes full effect for first three days; thereafter prorated.

***Reflects Israeli surprise night attacks, June 9-10.

OVERALL COMPARATIVE EVALUATION

Of all of the results of the quantitative analysis, the most significant are the relative Israeli-Egyptian CEVs for 1967 and 1973. In both instances the opponents were representative of the best military force the respective nations could at that time put in the field, with experienced officer corps, and with weapons of comparable quality and sophistication. In the 1967 War the Egyptians suffered the disruption resulting from moderate or substantial surprise; in the 1973 War the Israelis suffered disruption from practically complete surprise.

After allowing for the surprise disruption by identical procedures in both cases, and consistently applying the other variables of combat to the forces committed in a number of battles, the average Israeli CEV with respect to the Egyptians was 1.96 (although apparently increasing as time went on; see below). Following the identical procedure for the 1973 War the average Israeli CEV with respect to the Egyptians for the war was 2.16, although it was apparently only 2.06 after four days of combat. Whichever value we use (2.16 for the war as a whole, or 2.06 for a comparable period of four days of combat) the conclusion is the same. In the one instance the numbers suggest that the Israeli combat effectiveness superiority over the Egyptians had increased by about 10% in the intervening six years, in the other case that the gap had widened by 5%.

The significant thing is that, although the differential was still close to the same—about two-to-one factor in favor of the Israelis—the gap had not narrowed between 1967 and 1973; if anything it had widened. This is completely contradictory to the conventional reasoning, which has suggested that the Arabs did so much better in 1973 than in 1967 because they had learned from their 1967 lessons, and had utilized the time to improve themselves, while the Israelis, arrogant and overconfident, had not made comparable efforts.

Serious study of the matter, however, reveals not only that the conventional reasoning is wrong, it also reveals why it is wrong.

Demonstration that the 1973 performance is not an indicator of improved Arab performance is as follows:

1. In 1967, the Israelis started with surprise; the Arabs never recovered, in fact never had a chance to recover;
2. In 1973 the Arabs started with greater surprise than the Israelis achieved in 1967. Yet within three days the Israelis had recovered, and were fighting on equal terms with the Arabs. This is one of the most remarkable recoveries in military history.
3. One reason the initial Israeli frontier victories in 1967 were followed so quickly by Arab collapse is that the Israelis had eliminated the Arab air arm, and were able to use their own air in unchallenged, massive attacks that completed the demoralization of the Arab ground forces. Thanks to the acquisition of Soviet air defense weapons in great numbers between 1967 and 1973, in the latest war the Arabs were able to prevent the Israeli air from having a comparable field day.
4. In 1967 the overall Arab commander in chief, and the man directly responsible for the Sinai front, was a political appointee, a drunk and a drug addict, who seems to have been under both of the latter influences shortly after he learned of the destruction of his air force. In 1973 the Egyptians (and also the Syrians) were led by men who, if not the equal of their Israeli opponents (Ismail probably can be compared not unfavorably with them), were at least competent soldiers who did not lose their heads either in victory or in adversity.

Because of the assumptions involved, the overall campaign analyses shown in Figure 35 are not so reliable as those for the engagements. However, they suggest

an interesting quantitative corroboration of the qualitative arguments presented above.

The 1967 Jordanian campaign performance analysis suggests an Israeli CEV with respect to the Jordan Army of 2.10, which is 29% higher than the average CEV for the four battles analyzed. Since the Jordanian high command does not seem to have made any serious blunders during the campaign, it can be hypothesized that most of the 29% difference is due primarily to the effects of airpower on the overall outcome.

The 1967 Egyptian campaign performance analysis provides an Israeli/Egyptian CEV of 3.31, which is 69% higher than the average CEV for the four battles analyzed. If we accept the same hypothesis for the demoralizing and casualty-producing effect of the vigorous application of unchallenged airpower, this leaves 40% attributable to the inept leadership of Field Marshal Amer.

The 1967 Syrian campaign performance analysis indicates an Israeli CEV with respect to the Syrian Army of 6.40, which is 55% higher than the average Israeli CEV for the four battles analyzed. Again hypothesizing that 29% of this differential is due to the application of Israeli airpower, this leaves 26% attributable to the extreme ineptitude of the Syrian high command, which failed to employ its forces adequately, or to coordinate the operations of those units that were engaged.

In the Suez-Sinai 1973 campaign analysis, however, the relative Israeli-Egyptian CEV for the campaign is 20% higher than the average calculated for the battles analyzed on that front. This is consistent with a qualitative assessment that Israeli airpower did not significantly affect the overall outcome of these land campaigns, and that the high-level Arab leadership was somewhat less competent in performance than were the subordinate units. The overall analysis for the Syrian front shows an Israeli-Arab CEV 54% higher than for the engagements analyzed. This suggests that the Egyptian high command was about 34% more competent than that of the Syrians.

A comparison of the Israeli vs. Syrian performance in the two wars might, at first glance, appear to contradict the arguments presented above. In fact, however, the Syrian situation was unique, and cannot be the basis for any comparison of this sort.

The Syrian performance in 1967 was one of the most abysmal in the history of conventional warfare. While the Israeli performance on June 9-10, 1967, was commendable, the results achieved would have been impossible against even a moderately competent military performance. It is almost incredible to a military observer that any military force could have scaled the escarpment from the Huleh Valley to the Golan Plateau in a few hours against a force with the wealth of weapons and equipment available to the Syrians. One must draw the conclusion that, with a few individual exceptions, the Syrian Army was hardly better than a mob in uniform, commanded by individuals who could not cooperate with each other, or coordinate subordinates.

The reason for this is evident in the history of Syria between 1949 and 1967. There had been nine military coups d'etat, and after each coup the successful upstart had cleared out all potential rivals or enemies in the officer corps. The result was turmoil in the armed forces, with inevitable incompetence of the sort demonstrated in the 1967 War.

During the following winter, however, there had been one more coup d'etat, led this time by the then Minister of War, Air Force General Hafez al Assad. The new President again swept the senior commanders away (the evidence of the recent war suggests that this could not have done serious harm), and put in his own men, who have remained as the military leadership of the country ever since. Thus an improvement in Syrian performance, a major improvement, was inevitable, no matter what the Israelis, the Egyptians, or anyone else had also done in the meantime. It would seem surprising, in fact, if the improvement, with respect to the Israelis, had not been at least from a CEV of 0.24 to one of 0.40. There is no known information or technique available which can tell us whether it would have been greater if the Israelis had not also improved, as is evidenced from the analysis of operations against the Egyptians.

The Israelis had not only not fallen behind in the years between 1967 and 1973 but in fact had continued to widen the combat effectiveness gap between themselves and the Egyptians for many reasons, which can be summarized as follows:

- a. Continuous Israeli efforts to improve military performance at all levels and in all respects: training, schooling, mobilization plans and practices, etc.;
- b. A substantially higher R&D capability, and apparently a more intensive R&D effort;
- c. Sound, objective, Israeli professional military analysis of historical experience and current capabilities, in contradistinction to the Arab cultural tendency to allow emotion and wishful thinking to influence evaluation, planning and operational leadership.

First-hand observation of Middle East armies suggest that this situation has not changed since 1973.

An interesting phenomenon, so consistent as to demand recognition, is the fact that in 1973, as in 1967, a series of Arab defeats is invariably followed by declining combat effectiveness. There is no such phenomenon evident as a result of the few Israeli defeats in early October 1973, in fact quite the contrary. It is beyond the scope of this study to initiate any attempt to quantify what is almost certainly a morale and/or disruption phenomenon. It is quite germane to the objectives of the study, however, to note that the phenomenon exists, and must be given consideration in any efforts to assess Arab combat effectiveness in the event of future conflict.

CONCLUSIONS

1. Combat performance of the Israelis with respect to the opposing Arab armies in 1967, and the performance of the Arab armies with respect to each other, can be represented by the following numerical CEV comparisons:

Israelis	4.13	(1.63)	(1.96)	
Jordanians	2.53	(1.00)	--	(1.20)
Egyptians	2.11	--	(1.00)	(1.00)
Syrians	1.00			

or, in percentages:

- a. Israeli 63% superiority over the Jordanians;
- b. Israeli 96% superiority over the Egyptians;
- c. Israeli 313% superiority over the Syrians;
- d. Jordanian 20% superiority over the Egyptians;
- e. Jordanian 153% superiority over the Syrians;
- f. Egyptian 111% superiority over the Syrians.

2. Combat performance of the Israelis with respect to the opposing Arab armies in 1973, and the performance of the Arab armies with respect to each other, can be represented by the following numerical CEV comparisons:

Israelis	2.75	(2.16)
Egyptians	1.27	(1.00)
Syrians	1.00	

Or, in percentages:

- a. Israeli 116% superiority over the Egyptians;
- b. Israeli 175% superiority over the Syrians;
- c. Egyptian 27% superiority over the Syrians.

3. Special circumstances relating to the political and military leadership of Syria in 1967 and in 1973 do not permit the drawing of any firm conclusions from the comparative Israeli vs. Syrian comparisons in 1967 and 1973.

4. Between 1967 and 1973 the gap in combat effectiveness between the Israeli and Egyptian armies widened.

5. Save for the Syrians, there is no reason to believe that any other Arab armed forces improved their military effectiveness relative to the Israelis any more than the Egyptians; the Syrian improvement still leaves them considerably behind the Egyptians.

6. There is no reason to believe that the Arabs have improved their relative effectiveness with respect to the Israelis since 1943; rather it is likely that the qualitative gap has widened further.

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ARTILLERY SURVIVABILITY IN
MODERN WAR

Final Report

Unclassified Version of Report
Prepared for
Sandia Laboratories, Livermore
Under Contract No. 87-5400

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HISTORICAL EVALUATION AND RESEARCH ORGANIZATION
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HISTORICAL TRENDS IN ARTILLERY VULNERABILITY,
A HERO Concept Paper

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ARTILLERY SURVIVABILITY IN MODERN WAR (Phase One)

Introduction

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

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

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

"Campaigns to be analyzed are:

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

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

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

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

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

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

The undersigned assumes full responsibility for the report.

Dunn Loring, Virginia
October 13, 1976

T.N. Dupuy

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Part I. The Search for Data

Relevant Prior Studies

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

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

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

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

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

The October War

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

The Korean War

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

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

World War II

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

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

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

Manufacturing Data

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

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

More Data is Available

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

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

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

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

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

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Part II. The Data

General

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

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

US Data, World War II

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

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

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

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

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

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

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

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

US First Army

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

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

US Third Army

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

US Fifth Army

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

US Tenth Army

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

German Data

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

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

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

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Figure 2. WEHRMACHT STRENGTHS AND LOSSES, 1943-1944

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

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

Operation Designation Organization - Date	Av. Total Force Strength	Losses	%	/Day	Artillery Weapon	Total Str	Approx Ratio to Total Enemy*	Combat Losses Number	Losses to Air Losses	Losses to Artillery Losses	Losses to Other Losses
World War II											
Wehrmacht Field Army Combat Forces August '44	4,528,200	595,000	13.16	0.425	LFH MFH Hvy Arty Total L&M	8,524 2,898 1,461 12,883 11,422	1.170 248 104 0.38/1.0 1.522 1.418	936 198 83 1,217 1,134	10.98 6.83 5.63 9.45 9.93	0.354 0.220 0.183 0.305 0.320	
September '44	4,338,800	397,000	8.94	0.298	LFH MFH Hvy Arty Total L&M	8,230 3,023 1,430 12,683 11,253	336 113 13 0.38/1.0 449	269 90 10 369 359	3.27 2.92 0.70 2.91 3.19	0.109 0.099 0.023 0.097 0.106	
Average Month 1943-1944	4,525,194	182,917	4.04	0.135	LFH MFH Hvy Arty Total L&M	8,200 2,800 1,400 12,400 11,000	249 93 33 0.38/1.0 342	199 74 26 229 273	2.43 2.64 1.86 2.41 2.48	0.081 0.088 0.062 0.080 0.080	
East Front, World War II											
German Fourth Army November '43	179,279	8,844	4.93	0.164	Light M&H Total	290 180 470	9 9 18	8 8 16	2.76 4.44 3.40	0.092 0.148 0.113	1 1 2
							0.38/1.0		0.012 0.019 0.014	6 6 12	1 1 2
											0.012 0.019 0.014

*Estimate; may be high for Germans.

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

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

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

October War Data

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

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

Figure 4

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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Part III. Analysis

General World War II Analyses

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

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

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

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

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

¹Artillery counterbattery was the only significant cause.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Artillery Loss Distribution Analysis

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

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

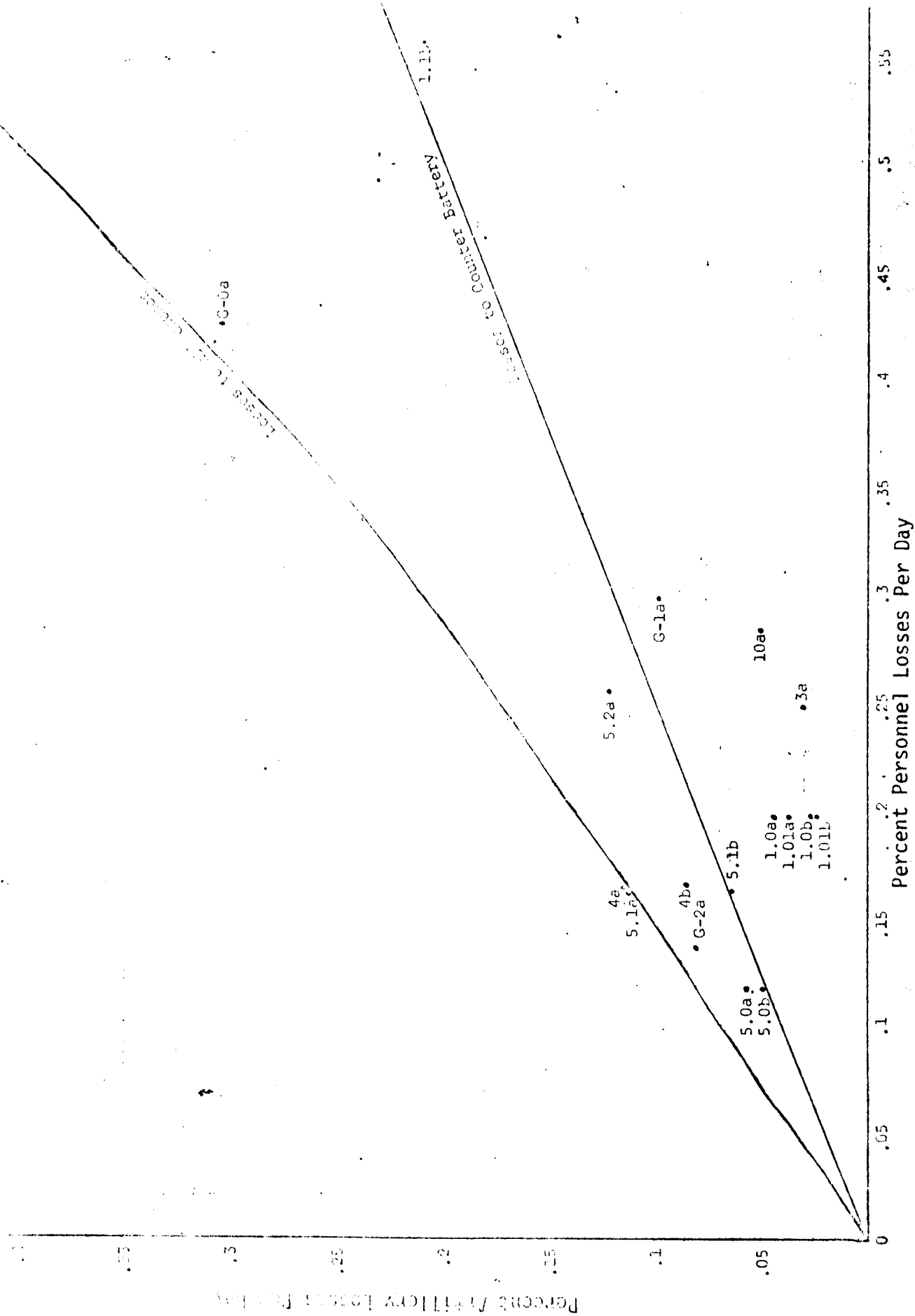
The most significant numbers in Figure 6 are those in the first two lines of Part B, showing the overall average comparisons of medium weapons to light weapons to heavy weapons losses, as follows:

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

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Figure 5

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



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Figure 6. ARTILLERY LOSS DISTRIBUTION ANALYSIS

Force	No.	Total Guns	Total Days	Total Guns Days/7110	Percent Loss Per Day				Loss Comparison			
					Light	Med	Heavy	ISM	Total	L/T	N/T	H/T
A. General												
US First Army, '44-'45	1.0a*	752	206	21.73	.049	.035	.013	.043	.037	1.32/25.68	0.95/20.64	0.35/7.61
	1.0b*				.025	.027	.013	.026	.023	-	-	-
	1.1a	648	11	1.00	.524	.341	-	.519	-	-	-	-
	1.1b				.223	.155	-	.210	-	-	-	-
US Third Army, '44	3a	893	92	(11.51)	-	-	-	-	.030	-	-	-
US Fifth Army, '43-'44	5.0a	292	370	15.23	.049	.081	-	.057	-	-	-	-
	5.0b				.026	.072	-	.029	-	-	-	-
	5.1a	304	68	2.90	.118	.097	-	.111	-	-	-	-
	5.1b				.065	.052	-	.063	-	-	-	-
	5.2a	324	26	1.27	.045	.034	-	.121	-	-	-	-
US Tenth Army, '44	10a	240	91	3.06	.063	.026	-	.050	-	-	-	-
Wehrmacht, Aug '44	G-0a	12,593	31	56.02	.354	.220	.183	.320	.305	1.16/64.97	0.72/40.73	0.60/33.61
Sep '44	G-1a	12,683	30	53.36	.109	.039	.023	.106	.097	1.12/59.76	1.02/54.23	0.24/12.65
'43-'44	G-2a	12,400	30	52.17	.081	.068	.062	.083	.080	1.01/52.69	1.10/57.39	0.78/40.43
German Fourth Army	4a	470	30	(1.96)	.092	(.148)	-	-	.113	(0.81/1.61)	-	-
B. Comparative Analysis by Weight Category												
				US and German	(Medium & Light losses/heavy Light & Heavy losses/medium Medium & Heavy losses/light							
				US Forces only (First Army only except for L/M)								
				German Wehrmacht only								
					2.19	1.83	1.00	1.00	1.00	1.00	1.00	1.00
					1.19	1.00	0.54	0.54	0.54	0.54	0.54	0.54
					1.00	0.84	0.46	0.46	0.46	0.46	0.46	0.46
					3.77	2.71	1.00	1.00	1.00	1.00	1.00	1.00
					1.40	1.00	0.37	0.37	0.37	0.37	0.37	0.37
					1.00	0.72	0.26	0.26	0.26	0.26	0.26	0.26
					2.05	1.76	1.00	1.00	1.00	1.00	1.00	1.00
					1.17	1.00	0.57	0.57	0.57	0.57	0.57	0.57
					1.00	0.86	0.49	0.49	0.49	0.49	0.49	0.49

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

Figure 7

ESTIMATED OCTOBER WAR ARTILLERY LOSS DATA
October War, 1973

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

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

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

General October War Analysis

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

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

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

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

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

PERCENT PERSONNEL LOSSES IN CASES OF DISASTERS (Revised)

A-1a

A-0a

I-3a

I-1a

I-2a

I-3b

I-0a

I-1b

I-2b

I-0b

I-3a

I-0a

I-0b

I-0c

Percent Personnel Losses Per Day

Percent Personnel Losses Per Day

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

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

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

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

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

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

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

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

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

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

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

Conclusions

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

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

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

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

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

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

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Recommendations

cial

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

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HISTORICAL EVALUATION AND RESEARCH ORGANIZATION

P. O. BOX 157, DUNN LORING, VIRGINIA 22027 560-6427

MEMORANDUM for Captain Denton West, USN; DNA

May 23, 1977

SUBJECT: Artillery Fire and Effect, US Ninth Army, Roer River Crossing,
February 23, 1945

1. This is an informal report in response to your request for information on the subject of the volume of artillery fire employed by the US Ninth Army in support of its crossing of the Roer River on February 23, 1945. Three principal secondary sources have been used as sources in the preparation of this report:

- a. Conquer: The Story of the Ninth Army, 1944-45 (Washington: Infantry Journal Press, 1947).
- b. Allen Mick, ed., With the 102nd Infantry Division through Germany (Washington: Infantry Journal Press, 1947).
- c. Charles B. MacDonald, The Last Offensive (Washington: GPO, 1974).

In order to obtain further details it would be necessary to devote a considerable amount of time to a research effort in the records of artillery battalions and other units in the Federal Records Center. Since it is believed that the following paragraphs, and the four enclosed charts, based on the three secondary sources, will provide most of the essentials which you mentioned, no attempt has been made to locate the additional materials. Our past research experience indicates, however, that much more detailed information is available, if the expenditure of time, effort, and funds is warranted.

2. Figure 1 is a compilation of the Ninth Army Artillery reports for February 22-23, 1945 (from 0600 on February 22 to 0600 on February 23). This report shows the number of artillery tubes that participated, including some tank destroyer and AAA guns that provided fire support, particularly during the pre-assault preparation. That preparation began at 0245 on February 23, and continued for 45 minutes; the assault began at 0330. The following points should be noted with respect to Figure 1:

- a. The number of rounds fired before 0245, February 23, is assumed to have been negligible; probably not over 2,000 rounds.
- b. It is assumed that between 0330 and 0600 on February 23 the artillery rate was the same as that of the rest of the day. The total expenditure between 0600 on February 23 and 0600 on February 24 of approximately 110,000 rounds, as shown on Figure 2, was probably made during roughly 10 hours of daylight (and an hour earlier and later) at an approximate rate of 9,200 rounds per hour. At this rate, in the two and a half hours between 0330 and 0600 about 23,000 rounds would have been fired.
- c. Based upon the two previous assumptions, it is assumed that about 45,000 rounds (approximately 65% of the total expenditure shown on Figure 1,

and about 1,000 rounds per minute) were fired during the preparation.

3. Since available data does not identify targets, the results of the artillery fire must be estimated. The data presented on Figure 3 provides a basis for calculating the theoretical effect of artillery fire during the total 24-hour period (0600 February 22-0600 February 23), and for the preparation. This chart repeats the information shown on Figure 1, for rounds expended by caliber, and converts these expenditures to the total areas that could theoretically have been covered, had there been no overlapping of effect. Thus, the total expenditure of 69,598 rounds for the 24-hour period theoretically could have covered an area of 56.18 million square yards. The area that theoretically could have been covered during the preparation would have been about 65% of that, or 36.52 million square yards. Assuming an approximately 50% overlap in the normal salvo or volley sheaf, the area that theoretically could have been covered during the preparation would have been 18.26 million square yards. It must be assumed, however, that each target was hit by five to ten volleys, thus the areas actually devastated during the preparation probably totalled about 2.43 million square yards.

4. The total front of the Army was 30 miles, although only a holding attack was made along approximately half of this distance. Had the volume of fire discussed above been spread equally on 36.52 million square yards on the far bank of the Roer River, the depth of the effective continuous coverage would have been about 690 yards; single volleys fired with a normal sheaf would have placed effective fire on the far bank of the river to a depth of 345 yards; and with an average of 7.5 volleys per target, the belt of devastation would have been about 50 yards deep. For the fifteen mile frontage of the main offensive effort, three-fourths of the preparation volume of fire would have covered theoretically to a depth of about 1,035 yards; single volleys with normal sheaf would have covered a belt about 515 yards deep; and with an average of 7.5 volleys per target, the devastated belt would have been about 70 yards deep. These figures are presented in tabular form below:

	Area Covered (1,000,000 yds ²)	Army Front 30 miles (Depth/yds)	Main Effort Front 15 miles (Depth/yds)
Theoretical maximum	36.52	690	1,035
Normal Sheaf 1 volley	18.26	345	520
Normal Sheaf 7-8 volleys	2.43	50	70

5. The sources available to us for this summary report do not provide very much information about the actual effectiveness of the preparation, except by implication. Although German resistance was encountered by the assaulting troops, it was not very effective. It was more than ten minutes after the preparation ended that German artillery was able to begin to respond to the assault. And total Ninth Army casualties on the day of the assault amounted to only 91 killed, 62 missing, and 913 wounded, out of a total of 11 divisions, or a total percent loss of less than 0.7%; which was only about 70% of the average daily U.S. division loss rate for active combat in the European Theater in World War II.

6. For a period of about fourteen hours intensity after 0330 on the 23rd, the intensity of fire was only about one-sixth of that during the 45-minute preparation. Nonetheless, during those fourteen hours a total volume of nearly 130,000 rounds was fired in support of the assaulting elements. This was a total volume about 2.83 times that of the preparation. Based upon the line of reasoning presented in paragraphs 3 and 4 above, and on the compilation in Figure 4, the Army's front could have been covered by effective belts of continuous artillery fire of varying intensities of devastation as shown below:

	Area Covered (1,000,000 yds ²)	Army Front 30 miles (Depth/yds)	Main Effort Front 15 miles (Depth/yds)
Theoretical maximum	103.35	1,950	2,930
Normal Sheaf 1 volley	51.68	975	1,465
Normal Sheaf 7-8 volleys	6.89	130	195

7. Please let me know if more information is required.

T.N. Dupuy
Executive Director

Figure 1

NINTH ARMY ARTILLERY AMMUNITION EXPENDITURE
0600 22 Feb - 0600 23 Feb 1945

Type	XIII Corps		XVI Corps		XIX Corps		34th FA Bn		Total Guns	Total Rounds
	Rounds	R/G	Guns	Rounds	R/G	Guns	Rounds	R/G		
25 pounder	13,715	67.2	204	187	7.8	24			24	187
105mm How M2	645	53.8	12	1,497	10.4	144	21,049	94.8	570	36,261
4.5" Gun	6,488	71.4	91	412	17.2	24	604	50.2	48	1,661
155mm How	1,385	55.8	25	582	12.2	48	7,042	65.2	247	14,112
155mm Gun M1	692	57.6	12	380	15.8	24	1,435	59.8	73	3,200
155mm Gun M12	369	30.6	12				443	36.9	24	1,135
8" How							1,204	51.9	35	1,573
8" Gun							283	47.2	6	283
240mm How							371	20.6	18	371
Other Weapons in an Artillery Role										
3" Gun	627	17.4	36				4,476	24.9	216	5,103
75mm How							1,508	20.9	72	1,508
75mm Gun	2,922	27.1	108						108	2,922
90mm Gun AA	1,342	12.9	104						104	1,342
Totals	28,185		604	3,058		264	37,761		654	69,598

Figure 2

NINTH ARMY ARTILLERY AMMUNITION EXPENDITURE
0600 23 Feb - 0600 24 Feb 1945

Type	XIII Corps			XVI Corps			XIX Corps			34th FA Bn			Total Guns	Total Rounds
	Rounds	R/G	Guns	Rounds	R/G	Guns	Rounds	R/G	Guns	Rounds	R/G	Guns		
25 pounder														
105mm How M2	19,588	96.0	204	2,600	108.5	24	30,056	135.2	222				24	2,600
4.5" Gun	340	28.4	12	9,016	63.2	142	847	70.6	12				568	58,660
155mm How	8,142	84.8	96	789	32.8	24	2,500	52.2	48				48	1,976
155mm Gun M1	1,183	49.2	24	2,500	52.2	48	12,222	113.1	108				252	22,864
155mm Gun M12	723	56.2	13	704	29.4	24	2,572	107.2	24				72	4,459
8" How	375	31.3	12				634	52.8	12				25	1,357
8" Gun							2,172	90.5	24				36	2,547
240mm How													6	271
													18	479
Other Weapons in an Artillery Role														
3" Gun	869	24.1	36				7,633	42.4	180				216	8,502
75mm How							4,100	56.9	72				72	4,100
75mm Gun	873	16.1	54										54	873
76mm Gun	597	16.5	36										54	898
90mm Gun AA	278	3.8	72	301	16.7	18							104	380
				102	3.1	32								
Totals	32,968		548	16,012		309	60,236		668		750	24	1,549	109,966

Figure 3

NINTH ARMY ARTILLERY EFFECT
0600 22 Feb - 0600 23 Feb 1945

Type	XIII Corps	XVI Corps	XIX Corps	Army Arty	Total Rounds/Caliber	Effective Area Covered* (yds ²)	Theoretical Area by Caliber (yds ²)
25 pounder		187			187	450	84,150
105mm How M2	13,715	1,497	21,049		36,261	750	27,195,750
4.5" Gun	645	412	604		1,661	850	1,411,850
155mm How	6,488	582	7,042		14,112		
155mm Gun M1	1,385	380	1,435		3,200	1,080	19,922,760
155mm Gun M12	692		443		1,135		
8" How	369		1,204		1,573	1,600	2,969,600
8" Gun				283	283	2,500	927,500
240mm How				371	371		
3" Gun	627		4,476		5,103		
75mm How			1,508		1,508	300	2,859,900
75mm Gun	2,922				2,922		
90mm Gun AA	1,342				1,342	600	805,200
Total	28,125	3,058	37,761	654	69,598	807.2	56,176,710

* From FM6-40, 1950.

Figure 4

NINTH ARMY ARTILLERY EFFECT
0600 23 Feb - 0600 24 Feb 1945

Type	XIII Corps	XVI Corps	XIX Corps	Army Arty	Total Rounds/Caliber	Effective Area Covered (yds ²)	Theoretical Area by Caliber (yds ²)
25 pounder		2,600			2,600	450	1,170,000
105mm How M2	19,588	9,016	30,056		58,660	750	43,995,000
4.5" Gun	340	789	847		1,976	850	1,679,600
155mm How	8,142	2,500	12,222		22,864		
155mm Gun M1	1,183	704	2,572		4,459	1,080	30,974,400
155mm Gun M12	723		634		1,357		
8" How	375		2,172	271	2,547	1,600	4,508,800
8" Gun				479	271	2,500	1,197,500
240mm How					479		
3" Gun	869		7,633		8,502		
75mm How			4,100		4,100	300	4,311,900
75mm Gun	873				873		
76mm Gun	597	301			898		
90mm Gun AA	278	102			380	600	228,000
Total	32,968	16,012	60,236	750	109,966	800.8	88,065,200